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The Canadian Entomologist

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CONTENTS

SILVER—Studies on the Silver-spotted Tiger Moth, *Halisidota argentata* Pack. (Lepidoptera: Arctiidae), in British Columbia 65

WRIGHT—The Olfactory Guidance of Flying Insects 81

BAIRD—Field Experiments with *Pseudomonas aeruginosa* (Schroeter) Migula to Control Grasshoppers 89

MORGAN and ANDERSON—Notes on Parathion-Resistant Strains of Two Phytophagous Mites and a Predacious Mite in British Columbia 92

REINHARD—Parasitic Flies of the Genus Mochlosoma (Tachinidae, Diptera) 98

DONDALE—Note on Population Densities of Spiders (Araneae) in Nova Scotia Apple Orchards 111

McGUFFIN—Biological and Descriptive Notes on Noctuid Larvae 114

EVANS—Two-Year Life Cycle of *Pseudohazis eglanterina* (Boisduval) (Lepidoptera: Saturniidae) 125

MUNROE—A New Subspecies of *Sparagmia gigantalis* Guenée (Lepidoptera: Pyralidae) 127

BOOK REVIEW—The Beetles of the Pacific Northwest. Part II: Staphyliniformia 128

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The Canadian Entomologist

Vol. XC Ottawa, Canada, February 1958 No. 2

Studies on the Silver-spotted Tiger Moth, *Halisidota argentata* Pack. (Lepidoptera: Arctiidae), in British Columbia[1]

By G. T. Silver
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Introduction

The silver-spotted tiger moth, *Halisidota argentata* Pack., is a potentially dangerous defoliator of Douglas fir in British Columbia. Natural control factors have always prevented populations from building up to destructive proportions.

The literature contains little information on this insect. Fletcher recorded the first outbreak of what was probably *H. argentata* in British Columbia in 1887 (2). Moths were identified as *H. sobrina* Stretch, but this form is now recorded only from California so it was probably *H. argentata.* The outbreak, probably on southern Vancouver Island, was reported as "committing great depredations on the spruces here." Mathers found *H. argentata* at Chilliwack in the Fraser River Valley in 1934, but there was no report of an outbreak (4). A few larvae were collected on southern Vancouver Island from 1936 to 1952. In 1953 a considerable number of colonies were observed, and the following year the silver-spotted tiger moth was in infestation proportions. In 1955 the outbreak increased in intensity, and spread northward to the limit of its known range. A survey in the spring of 1956 failed to find a single colony south of Lantzville, and the population in the northern portion of the range was greatly reduced.

Halisidota argentata was described by Packard in 1864 (5). Dyar, in a discussion on the genus *Halisidota,* which is exclusively American, recorded three races of *H. argentata*: *subalpina* French, inhabiting the Rocky Mountain region; *argentata,* proper, in the Sierra Nevada of California and the Pacific Northwest; and *sobrina* Stretch, in the coastal region of California (1). Keen refers to only one variety, *H. argentata sobrina* Stretch, feeding on Monterey pine in California, and gives the range of *H. argentata* Pack., as extending from the Atlantic to the Pacific, with the western form found in the Western States (3).

This paper deals with the species in British Columbia identified as *H. argentata* by D. F. Hardwick of the Systematic Unit, Ottawa.

Distribution and Hosts

In British Columbia *H. argentata* is restricted to the southwestern corner of the province. It occurs on the eastern side of Vancouver Island from Jordan River as far north as Campbell River, but not in the western wet belt of the Island. On the mainland it extends from Vancouver north to Bute Inlet, and it is also found on the Channel Islands. It has been found inland as far as Chilliwack in the Fraser River Valley. The heaviest populations occur near tide water, but colonies have been found up to 1,500 foot elevations.

Douglas fir, *Pseudotsuga taxifolia* (Poir.) Britt., is the preferred host, but larvae have been collected from and reared through to maturity on western hemlock, *Tsuga heterophylla* (Raf.) Sarg., lodgepole pine, *Pinus contorta* Dougl., and grand fir, *Abies grandis* (Dougl.) Lindl. Larvae have also been collected from western red cedar, *Thuja plicata* Donn, Sitka spruce, *Picea sitchensis* (Bong.)

[1]Contribution No. 411, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

Carr., mountain hemlock, *Tsuga mertensiana* (Bong.) Carr., alpine fir, *Abies lasiocarpa* (Hook.) Nutt., and amabilis fir, *Abies amabilis* (Dougl.) Forb.

All age classes of Douglas fir are attacked from 2-year-old nursery seedlings (Fig. 13) to overmature trees.

Description of Stages

Adult

The forewings are brown with distinctive markings. There are five cream-coloured spots along the costal margin; the other markings are white (Figs. 6 and 7). The hind wings are white with several light brown markings on the apex. The abdomen is white. The moths can be sexed easily by the antennae which are pectinate in the male and filiform in the female. The female is invariably larger than the male with an average wingspan of 48.5 mm. (range 45-53 mm.) compared with the male wingspan of 41.9 mm. (range 39-44 mm.).

Egg

The eggs are hemispherical in shape, about 1.0 mm. in diameter and 0.75 mm. high. Newly laid eggs are light green with a dark green circular centre about 0.65 mm. in diameter.

Larva

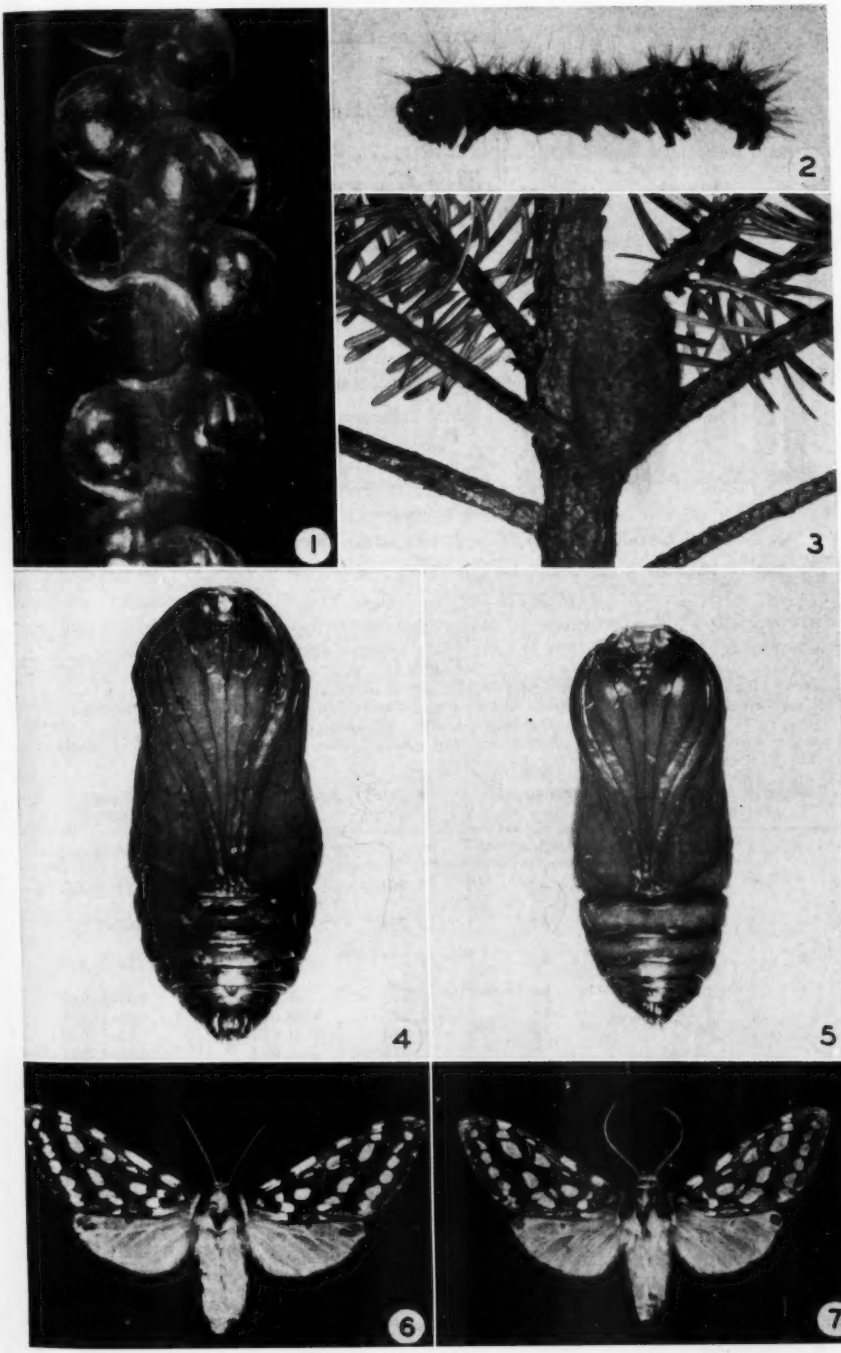
Number of instars—Larvae reared from eggs were preserved in alcohol by instars for the first five stages. Later stage larvae were reared individually to determine accurately instar changes. These first rearings were conducted during the normal developmental period in the insectary. To verify the results of the first experiment, individual rearings were set up in the laboratory and the larvae forced through from the second instar to maturity without hibernation. Head widths were measured to the nearest 0.051 mm.

Considerable trouble was experienced in rearing this insect. The barbed setae break off easily and the tiny tips become embedded in the fingers and any part of the body touched by the hands, producing red swellings which are very irritating. Mature larvae and cocoons are particularly notorious for this. Most of the insectary staff were allergic and consequently only a few people could be used on *Halisidota* work.

The head widths of larvae reared during the normal developmental time are shown in Fig. 8. The first six instars are fairly well defined, but measurements of subsequent instars overlapped. Even when the head widths were plotted by sexes there was considerable overlap. A review of the records disclosed that both male and female larvae could have either seven or eight instars. The females were about evenly divided, but only four of 18 males had eight instars.

Without the advantage of individual rearings it would have been impossible to determine the number of instars or to ascertain the reason for the discrepancy. These differences, which are shown in Table 1, are summarized below. The mean head width of male larvae is smaller than the mean head width of female larvae in the same stadium. There is a spread in head widths of larvae in the same instar depending on whether they have seven or eight instars. The largest mature larvae are those with eight instars. It is, therefore, easy to see why such overlap occurred in the last two instars.

Figs. 1-7. *H. argentata* 1. Empty egg shells (x 20); 2. Partly grown larva (x 5); 3. Cocoon (x 0.9); 4. Female pupa (x 4); 5. Male pupa (x 4); 6. Female moth (x 1.3); 7. Male moth (x 1.3).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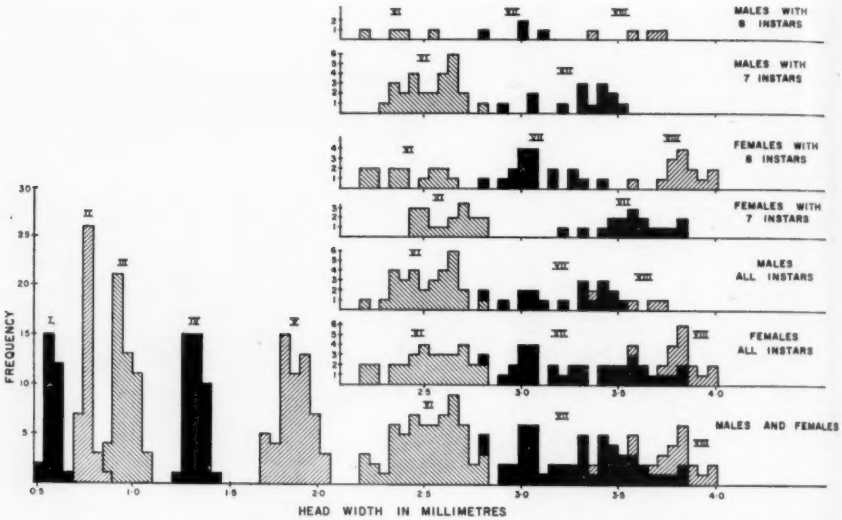


Fig. 8. Head capsule width of *H. argentata* larvae reared during normal developmental period.

TABLE I

Head Capsule Widths of Male and Female Larvae of *H. argentata*. Larvae Reared During Normal Development Period. Stadia I to IV were Mass Reared, other Stadia were Reared Individually. Victoria, 1954.

Stadium	Sex	No. measured	Mean width (mm.)	S.D.	Range (mm.)
1	M & F	30	0.581	0.039	0.510–0.663
2	M & F	37	0.765	0.032	0.714–0.867
3	M & F	51	0.959	0.028	0.867–1.071
4	M & F	42	1.321	0.045	1.224–1.428
5	F (7)[1]	20	1.872	0.070	1.785–1.989
	F (8)[2]	12	1.775	0.071	1.683–1.887
	M (7)	22	1.846	0.073	1.683–1.989
	M (8)	4	1.775	0.087	1.683–1.887
6	F (7)	18	2.621	0.126	2.408–2.805
	F (8)	14	2.417	0.161	2.193–2.652
	M (7)	27	2.540	0.134	2.295–2.805
	M (8)	4	2.372	0.153	2.193–2.550
7	F (7)	17	3.570	0.168	3.213–3.825
	F (8)	18	3.080	0.155	2.805–3.417
	M (7)	14	3.305	0.181	2.907–3.519
	M (8)	4	2.984	0.128	2.805–3.111
8	F (8)	14	3.825	0.106	3.570–3.978
	M (8)	4	3.583	0.158	3.366–3.723

[1]Larvae with seven stadia.
[2]Larvae with eight stadia.

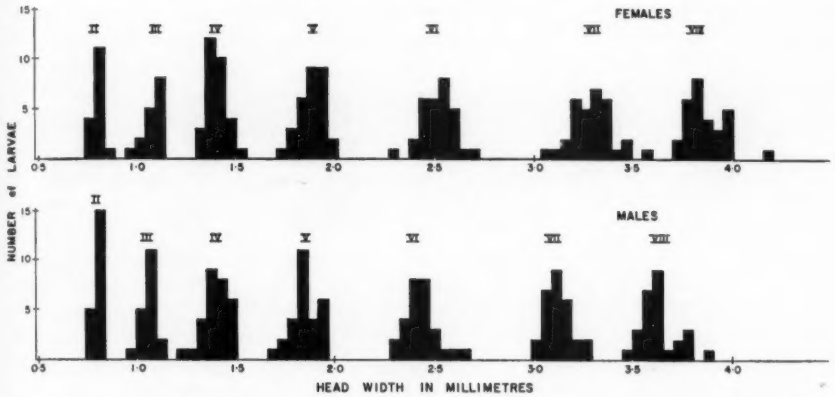


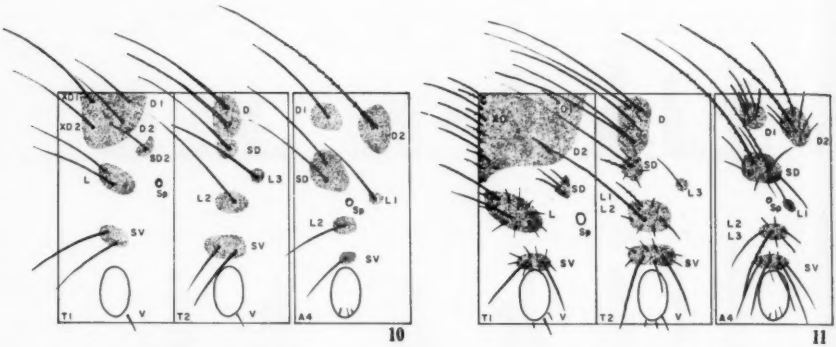
Fig. 9. Head capsule widths of *H. argentata* larvae reared to maturity without hibernation.

A second series of larvae, reared in the laboratory individually from the second instar, showed altogether different results. The head widths were plotted (Fig. 9), and the measurements summarized in Table 2.

Larvae of both sexes, without exception, required eight instars to complete their development. All instars in both sexes were well defined with no overlapping. The female larvae were larger, but although this difference showed in the third instar it was not very obvious until the sixth. The eighth-instar female larvae from both tests were larger than male larvae by approximately the same amount, i.e., 0.242 mm. in the normal developmental period compared with 0.230 mm. in the forced stock.

TABLE II
Head Capsule Widths of Male and Female Larvae of *H. argentata*.
Larvae Forced Reared. Victoria 1954–1955

Stadium	Sex	No. measured	Mean width (mm.)	S.D.	Range (mm.)
2	F	16	0.806	0.028	0.765–0.867
	M	20	0.806	0.023	0.765–0.816
3	F	16	1.086	0.044	0.969–1.122
	M	19	1.056	0.037	0.969–1.122
4	F	30	1.408	0.049	1.326–1.530
	M	29	1.397	0.064	1.224–1.479
5	F	30	1.882	0.063	1.734–1.989
	M	28	1.846	0.068	1.683–1.938
6	F	30	2.519	0.081	2.295–2.703
	M	28	2.428	0.082	2.295–2.652
7	F	31	3.284	0.089	3.060–3.468
	M	28	3.121	0.052	3.009–3.264
8	F	30	3.856	0.112	3.570–4.182
	M	27	3.626	0.094	3.468–3.876



Figs. 10-11. Setal patterns of *H. argentata* larvae: 10. First instar; 11. Third instar.

The reason for the different number of instars is uncertain. One explanation is that the larvae which were laboratory reared were under more uniform conditions of temperature and food, whereas the first group was reared in the insectary and, therefore, subjected to more variable weather not unlike natural conditions. It is, therefore, assumed that field populations would have either seven or eight instars and that the overlap in head widths would prevent separation of the larval stages by head width measurements. This assumption was supported by measurements of mature larvae collected in the field, which corresponded to the measurements shown in Fig. 8.

Description of larvae—The first-instar larva has a light brown to pale orange head and a yellowish-white body. The prothoracic shield is brown, darker than the head capsule. The thoracic legs and anal plate are brown, the prolegs body colour. The setae rise from prominent brown verrucae (Fig. 10). All the setae are pale with the exception of two long black barbed setae rising from D2 verrucae on abdominal segments 1 to 7. The crochets on the prolegs number 6 or 7.

The body of the second-instar larva is about the same colour as the first instar but the head is usually a darker brown. The most prominent feature is the replacement of the long black setae with pale setae. Several larvae examined had one short black barbed seta on the D2 verrucae, but this was unusual. All verrucae, in addition to the primary setae, bear a number of short setae. The crochets on the prolegs number 8 or 9.

The head, prothoracic shield, anal plate, and verrucae of the third-instar larva are reddish-brown to brown. Pigmentation on the dorsal and lateral sides gives the body a brownish appearance; the ventral side is pale. The setae along the anterior edge of the prothoracic shield are long, extending forward over the head. There are up to seven short black barbed setae, five along the anterior edge of the shield, the other two posterior (D1, D2). Seven long white barbed setae, rising from verrucae D and SD on the mesothoracic segment, curve forward over the head. Verrucae D and SD are touching (Fig. 11). Short black setae are present on verrucae SD, L1, and L2. Abdominal segments 2 to 7 have five short black barbed setae on verrucae D1 and one on verrucae D2. The crochets on the prolegs number 9 or 10.

The fourth-instar larva has a dark brown to black head, the body is brown dorsally and laterally, and light brown ventrally. The prothoracic shield, anal

plate, verrucae, and thoracic legs are dark brown. The larva is assuming the characteristic arctiid appearance with dorsal tufts of 7 or 8 short black setae on abdominal segments 2 to 7 inclusive. The crochets on the prolegs number 9 to 11.

The head, prothoracic shield, anal plate, and thoracic legs of the mature larva are black. Many barbed setae rising from verrucae cover the entire body and head. The basic colour is brown, but there are variations.

A large number of long yellow and brown setae rising from the anterior edge of the prothoracic shield extend forward over the head and hide it. There are also a large number of shorter, more erect black setae. Lateral setae are reddish-brown in colour. The mesothoracic segment has a pair of dorsal tufts composed of up to 15 black setae flanked on either side by a few yellow setae. The tufts on the metathoracic segments are similar but with more yellow setae along the mid-dorsal line. Other setae are reddish-brown but there are short black setae in all verrucae.

Abdominal segments 1 to 8 inclusive are characterized by dorsal clusters of thick, erect, black setae flanked by yellow setae. Other setae are reddish-brown. The first and seventh abdominal segments bear prominent lateral tufts of black setae. The second segment also has a black lateral tuft, but not as conspicuous as the other two. The number of black setae in the dorsal tuft on the ninth abdominal segment is reduced with the yellow setae prominent. The prolegs possess uniordinal crochets in a heteroideous mesoseries arrangement, 26 to 29 in number.

Cocoon

The oval-shaped cocoon is brown, the same colour as the larva, as it is constructed from the setae woven together with silk (Fig. 3). The male cocoon averaged 20.6 mm. long by 11.8 mm. wide (max. 23 x 13 mm.), and the slightly larger female cocoon averaged 22.9 mm. long by 13.2 mm. wide (max. 25 x 14 mm.).

Pupa

The pupa is light amber in colour at first, later changing to reddish-brown or brown. There are no setae. The cremaster has many small, slender hooks. The appendages and the dorsal segments are outlined in black. The slit-like spiracles are black and conspicuous. The pupae are easily sexed by the genital pore which in the male is on the ninth venter and in the female on the eighth venter (Figs. 4 and 5). The male pupae averaged 16.5 mm. long by 6.7 mm. wide, compared with the female pupal measurements of 18.8 x 7.7 mm.

Life History

Adults

Adult emergence for 1954 and 1955, as observed in the insectary, is shown in Fig. 12. In 1954 most of the adults emerged from July 23 to August 16, and in 1955 from July 22 to August 13. Males and females emerged at about the same times. Of a total of 1,808 adults 50.9 per cent were females, indicating a 1 to 1 ratio.

Few adults were observed in the field so little is known about flight habits. Caged moths were very active, and the few moths seen in the field appeared to be strong fliers.

Longevity of adults was recorded in all matings. Both sexes lived considerably longer when the moths mated. (Table 3).

Mating and Oviposition

Two pairs of adults were observed mating.

TABLE III
Longevity of Unfed *H. argentata* Adults in Days.
Victoria, B.C. 1954 and 1955

	Matings which produced eggs				No eggs laid	
	Eggs hatched		No eggs hatched			
	Male	Female	Male	Female	Male	Female
Average	12.2	10.3	11.1	8.7	9.2	6.6
Mode	12	8	10	8	5	5
Range	4–22	4–18	3–21	4–18	3–18	3–17
Number	87	87	134	134	45	45

At 4.35 a.m. (first sign of dawn) on July 15, two moths which had emerged the day before were observed mating. They were on an inclined piece of cardboard with the female facing the top. The male's wings vibrated slowly for a minute, then rapidly for 2½ minutes before the moths separated. The female started laying fertile eggs that afternoon.

On August 1 a female emerged and was caged with a male. On August 4 three eggs were laid. On August 5, at 11.47 a.m. the adults were observed mating on the bottom of the cage. The moths remained in a mating position until the morning of August 8. The female laid 325 eggs that day, 80 more the next day, and died three days later. Eighty-seven per cent of the eggs hatched.

Mathers (4) reported observing one pair of moths mating, the female laying eggs the following day.

Caged females laid eggs on foliage and anywhere in the cages and jars. Most females deposited more than one egg mass even when foliage was provided. No egg masses were observed in the field, but oviposition sites may be indicated by the location of colonies of developing larvae. Nearly all colonies were on the southern and western sides of the trees. Most trees had one to five colonies, the maximum was 14. Only scattered trees were infested.

Temporary plots were laid out in 1954 to determine if the insect preferred certain trees. A total of 43 trees had 118 colonies. The next year 56 trees contained 170 colonies, but only 56 colonies were on 24 of the trees infested the previous year. Therefore there was no evidence that certain trees are preferred.

Ninety per cent of the females laid their first eggs three to five days after the adults were caged. Three-quarters of the moths laid all their eggs in one day, and 90 per cent in two days. The maximum egg laying period was five days.

Fecundity

Eighty-six successful matings averaged 300 ± 126 eggs with a range of 1-539. The following summary shows the number of eggs laid by classes.

Number of eggs	Number of matings
1 — 200	20
201 — 300	22
301 — 400	29
401 — 500	14
500 +	1

The number of unlaid eggs were counted for 35 moths. The average number of total eggs was 406 with a maximum of 554.

Fecundity studies were carried out on moths which developed from seven- and eight-instar larvae. There was no significant difference between the number of eggs laid for the two groups of adults. The results are shown below:

	Moths from seven-instar larvae	Moths from eight-instar larvae
Number of matings	19	17
Average number eggs laid	177.1	212.5
Average number unlaid eggs	197.7	188.7
Total	374.8	401.2

Egg

Fourteen to 16 days after being laid the green centre of the egg turned a darker green, and the periphery became translucent. Four to six days later whitish spots appeared on the dark green centre, later turning to brown. Several days before hatching, the head capsule and body with long black setae were clearly visible. Movement occurred one or two days before hatching. Larvae usually emerged the same day they started chewing their way through the chorion, but in several instances two days were required before the emergence hole was large enough. Some larvae started chewing in several places before selecting a final point. The emergence holes are ragged, variably shaped, and are not in a consistent position (Fig. 1). The eggs from which the above data were recorded hatched in 22 to 26 days. The average length of the egg stage, based on eggs from 82 matings, was 30 days with a range of 19 to 42 days.

Larvae

Development and habits were determined from insectary rearings and by placing colonies of larvae on trees where they could be observed. Each colony contained larvae from one female.

Under insectary conditions larvae emerged from the eggs from August 17 to September 22. The peak emergence was September 1 and 2. Within individual egg masses the average length of time for emergence, from the first to the last, was eight days with a maximum of 22 days. However, in 60 colonies in which daily emergence was counted, 88.5 per cent of the larvae emerged the first day.

Larvae of the silver-spotted tiger moth are gregarious in the early instars. When not feeding the larvae cluster together, usually inside a loose web. Usually only one larva is found feeding on a single needle.

Because of the difficulty in finding natural colonies in the field until spring, first-instar larvae were set out on trees in colonies of 100 on September 9, 1954. Instar changes were noted from time to time during the winter until all colonies disappeared in May (Table 4). As larval emergence extended from mid-August to the last half of September, some spread in dates would be expected. In 1955 some field collections were made and the larvae separated into instars. The results are shown in Table 5.

There is no real hibernation period on southern Vancouver Island. Larvae were observed feeding on fine sunny days throughout the winter of 1954-55, and development within individual colonies, both in instar changes and changes in the percentage of larvae in different instars, were observed from November to April. The winter is passed in the third, fourth, and fifth instars, with usually one moult during the winter months.

TABLE IV
Dates at which Different Larval Instars were found in the Field. Victoria, 1954–55

Instar	First date	Last date
I	Sept. 9	Sept. 27
II	Sept. 19	Nov. 26
III	Oct. 12	Feb. 18
IV	Nov. 16	May 3
V	April 5	May 10
VI	May 9	colonies disappeared
VII	May 15	colonies disappeared

Larvae start regular feeding as soon as the weather becomes relatively warm, usually in April. The colonies feed on the lateral branches on which they overwintered. They remain on one branch, completely stripping it of needles for three to five feet from the tip (Fig. 14). Then the colony migrates to an adjacent branch. Up to four branches can be heavily defoliated by a single colony. In 1954 the colonies broke up during early May. Large masses of larvae moved to the terminals of the trees and heavily defoliated up to five feet of the top (Fig. 15). Then the larvae descended, and either scattered throughout the entire tree crown, or left the tree completely. A large number of shed head capsules were always found in the terminals, held by the large amounts of silk laid down by the larvae.

At this point it was difficult to follow the habits of the larvae. Although large numbers of larvae left the trees it was doubtful if they crawled down the trunk. Six trees containing a large number of colonies were banded with tanglefoot but no larvae were caught descending although two larvae were trapped ascending. Large numbers of larvae were observed on the ground after a heavy wind, apparently either blown or shaken off.

Sometimes the infested tree was almost completely deserted. One small tree with one web was cut and lowered onto beating sheets. Only two immature

TABLE V
Percentage of Larvae in Different Instars. Vancouver Island, 1955

Date	Per cent of larvae by instars				
	III	IV	V	VI	VII or VIII
Jan. 21	63.4	36.6			
Feb. 23		43.3	56.7		
April 21	27.5	70.5	2.0		
May 16				18.8	81.2
May 19				10.3	89.7
May 20				4.8	95.2

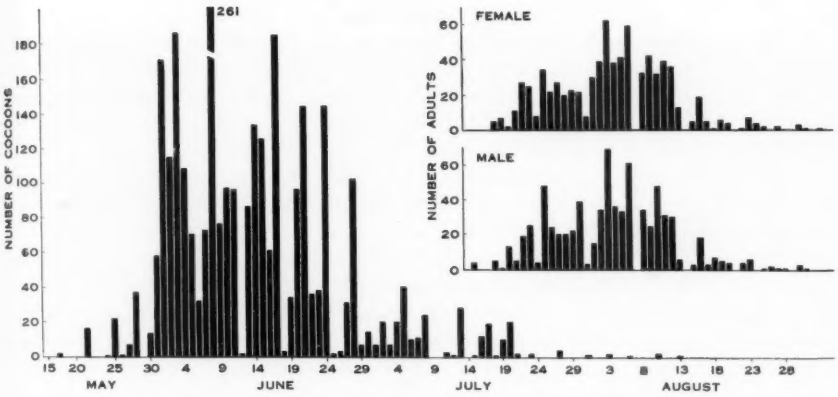


Fig. 12. Cocoon spinning and adult emergence dates of *H. argentata.*

larvae were found. From May 13 to May 30 large numbers of larvae were found on all varieties of shrubs, bushes, grassy plants, and the lower tree branches, including those of trees which had no colonies. Over 20 larvae were picked off a small isolated Douglas fir 75 feet from the nearest tree bearing overwintering colonies.

At 10 a.m. one morning larvae were observed moving in a westerly direction across the road from a heavily populated stand. Numerous larvae were dead on the pavement. The larvae appeared capable of orienting themselves well. When rolled off the highway by the airstream caused by passing vehicles they would immediately start moving back in the original direction.

In 1955 two trees were selected and stages built around the trees to facilitate examination. Colonies were placed on the lateral branches in the spring with the object of finding if the larval movements were related to instars. Unfortunately the consistent migrations so obvious in 1954 were not repeated. Some larvae moved to the terminals, but in general the colonies broke up and scattered. Consequently, top feeding was negligible in 1955. Colonies broke up when most larvae were in the ultimate or penultimate instar.

The amount of foliage consumed per larva was determined by individual rearings in which the number of needles eaten were recorded. High mortality prevented data being gathered on the third and fourth instar. First-instar larvae fed on or consumed an average of 5.7 needles (range 3-8), and the second instar 7.1 (range 3-9). Larvae from the fifth instar on, fed on an average of 702 needles each. The portions and percentages of needles fed upon by the older larvae were as follows: entire needles eaten, 75.4, only tips of needles eaten, 5.1, half of needles consumed, 2.6, needles chewed off at the base but not consumed, 16.9 per cent. The silver-spotted tiger moth may, therefore, be regarded as a fairly economical feeder as over three-quarters of the needles attacked are completely consumed. In the last instar, 33.4 per cent of the total feeding took place, compared with 28.8 per cent in the penultimate, and 16.3 per cent in the preceding instar.

No top kill or permanent damage to branches was observed. Feeding occurs in the spring and early summer, and even complete defoliation does not damage the buds, which produce a normal complement of foliage (Fig. 16).

Resting Stage

As stated previously the mature larvae scatter throughout the trees and the understory. Consequently cocoons are exceedingly difficult to find in the field. They have been found on the underside of lower branches where their colour blends well with the natural surroundings (Fig. 3), on the trunks of trees, on shrubs, and on dead twigs on the forest floor.

In the insectary the first cocoon was recorded May 17 and the last on August 13, almost a three-month period. Most of the insectary reared larvae spun cocoons during June (Fig. 12).

Records on 274 individual cocoons showed that the elapsed time between cocoon spinning and pupation averaged seven days with a range of two to 11 days.

Characteristically, in this species the pupal stage is relatively long. Adults emerged an average of 45 days after pupation, or an average of 52 days after the cocoons were spun. The range was 36 to 51 days after pupation.

Natural Control

Control work was limited to the following factors.

Parasites—Mortality attributed to parasitism is shown in Table 6. The species and their abundance are shown in Table 7. The latter table is not complete as all the parasites have not been identified. *Uromacquartia halisidotae* Tns. and *Meteorus hyphantriae* Riley were the most numerous parasites. It is interesting to note that *U. halisidotae* accounted for the larger part of the 1955 parasitism, but *M. hyphantriae* was predominant in 1956 when the population decreased sharply.

U. halisidotae was reared only from larvae collected between January 21 and July 12. This would indicate that the larvae are parasitized in the fall and that the parasite overwinters in the host. Larvae were killed by the parasites between April 6 and June 6. The parasite larvae pupated as soon as they emerged from the host. The pupal stage lasted an average of 37 days, the adults emerging between April 29 and July 15 with most of the emergence occurring in June.

M. hyphantriae was recovered only from larvae collected between April 20 to June 6. The host larvae were killed from April 27 to June 24. Adults emerged from June 14 to July 28 after an average of 28 days in the resting stage.

Rileymia adusta (Lw.) emerged from pupae with the exception of one which emerged from a larva. This species was recovered only in 1954. The hosts were collected as larvae from May 14 to May 20, and reared through to the cocoon stage before being killed by parasites between June 8 and July 14. Only two adult emergence dates are available, July 30, 1954, and March 14, 1955, so it is uncertain if all or only a portion of this species overwinters in the cocoon stage.

Two specimens of *Rileymia triseta* Brks. were recovered from larvae and 24 from pupae. Both larval parasites were from a single collection made on May 17, 1954. In 1955, 18 of the 21 parasites were from one larval collection made on May 1. The host pupae were killed June 22 to August 10. The parasites overwintered as pupae and the adults emerged from March 20 to April 5 under insectary conditions.

Figs. 13-16. *H. argentata* on Douglas-fir: 13. Colony of larvae on 2-year-old nursery stock; 14. Typical defoliation of lateral branch showing remains of old web; 15. Heavily defoliated terminal; 16. Photograph taken in August showing recovery of branch completely defoliated in the spring.

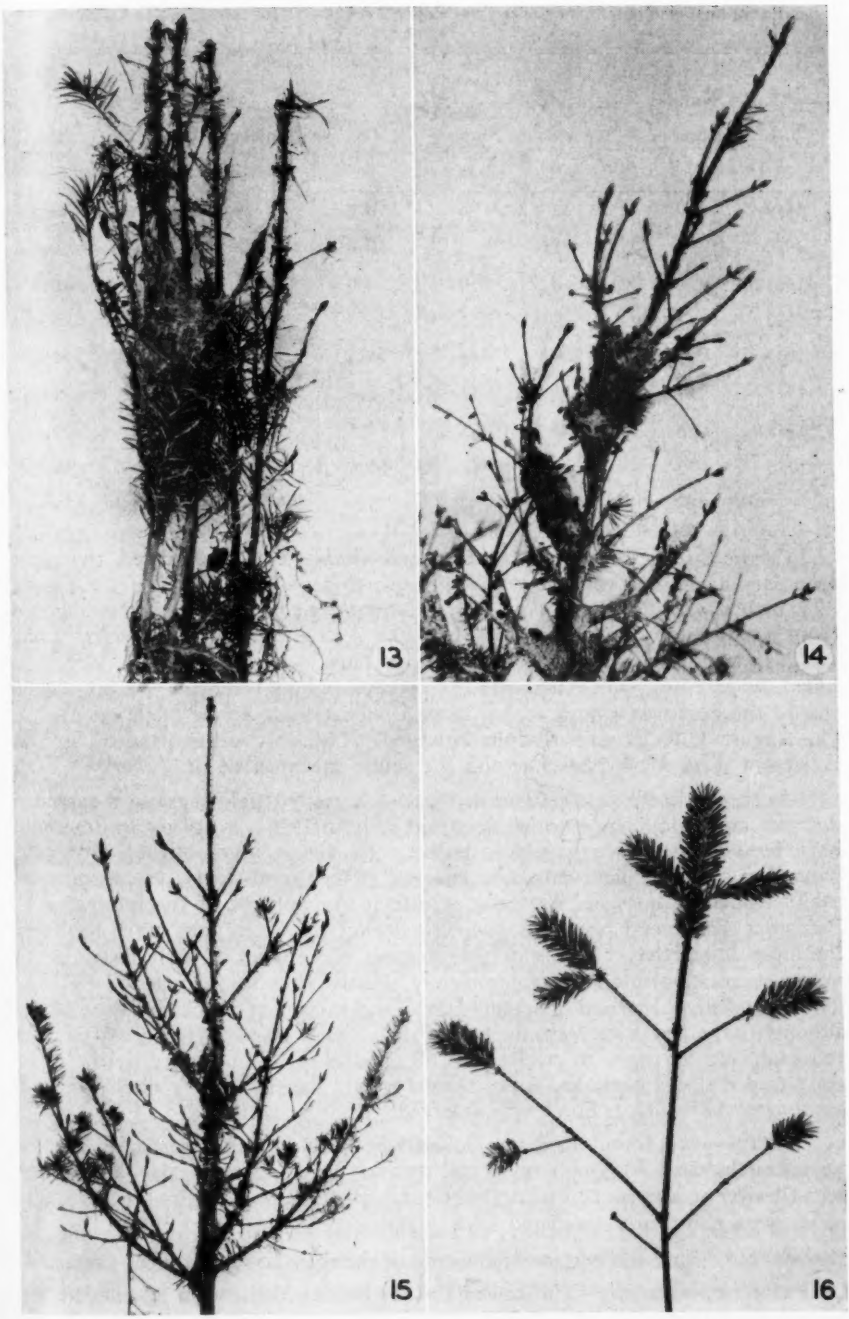

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TABLE VI
Percentage of *H. argentata* Larvae and Pupae Killed by Parasites in British Columbia, 1949 to 1956

Year	Number of collections	Larvae			Pupae		
		Number reared	Number died of parasites	Per cent	Number reared	Number died of parasites	Per cent
1949	34	32	6	18.8	29	4	13.8
1950	4	5	0	0.0	2	0	0.0
1951	4	6	0	0.0	4	0	0.0
1952	5	8	1	12.5	4	0	0.0
1953	34	258	42	16.3	187	4	2.1
1954	101	2,124	30	1.4	1,885	24	1.3
1955	38	1,800	204	11.3	1,165	27	2.3
1956	12	446	84	18.8	240	47	19.6

Of the three specimens of *Tachinomyia similis* (Will.) recovered, two were from larvae and one from a pupa. Only one *Rogas* sp. was reared, from a larva. This record was obtained in 1949. One *Compsilura concinnata* Mg. was obtained from a pupa, the adult emerging July 20. A hyperparasite, *Dibrachys cavus* (Wlk.), was found in two collections. A pupa collected July 19, 1955, was killed by parasites. On August 15, 17 *D. cavus* adults emerged. In the second record the host was a pupa reared from a collection of larvae made on May 2. On August 3, 86 *D. cavus* adults emerged. The only other parasites in this collection were *M. hyphantriae* and the single specimen of *M. bakeri.*

As shown in Table 6 parasitism was not heavy enough to cause the sudden decrease in the population which occurred early in 1956. Pupal parasitism could have been heavier as only a few pupae were found in the field. However, parasitism has been observed to be heaviest in the larval stage. It can only be assumed that parasites did not assist greatly in the collapse of the infestation.

Predators—Of several predators observed during this study ants were probably the most destructive. A considerable number of colonies of early-instar larvae under observation disappeared completely shortly after being molested by ants. They attacked and carried off young larvae, and they even attacked mature larvae although large larvae successfully fought off solitary attacks. In one instance it required between eight to twelve ants 80 minutes to kill a mature larva. Ants also invaded sleeve cages and killed several gravid females. Only one species of ant, *Formica obscuripes* Forel, was observed.

Spiders were found in many colonies, particularly early-instar and overwintering larvae. Although no actual attacks were observed, populations decreased after spiders were found associated with the larvae. Earwigs and millipedes were also found associated with colonies.

Disease—No disease was encountered in any of the eggs, larvae, or pupae examined.

Overwintering mortality—The causes for the sudden collapse in population are largely speculative, but this insect appears to be very vulnerable to adverse

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TABLE VII
Species and Number of Parasites Reared from *H. argentata* in British Columbia. Victoria. 1949–1956

Parasite species	Number of parasites							
	1949	1950	1951	1952	1953	1954	1955	1956
Uromacquartia halisidotae Tns.	0	0	0	6	0	15	114	3
Meteorus hyphantriae Riley	0	0	0	2	0	3	33	61
Meteorus bakeri Cook and Davis	0	0	0	0	0	0	0	1
Meteorus sp.	2	0	0	0	0	2	11	0
Rileymia triseta Brks.	1	0	0	0	0	5	21	0
Rileymia adusta (Lw.)	0	0	0	0	0	12	0	0
Tachinomyia similis (Will)	3	0	0	0	1	0	0	0
Compsilura concinnata Mg.	0	0	0	0	0	0	1	0
Dibrachys cavus (Wlk.)	0	0	0	0	0	0	1	1
Rogas sp.	1	0	0	0	0	0	0	0

weather conditions. This is particularly true of overwintering larvae which break hibernation and start feeding in fine periods during the winter. These larvae are very susceptible to sudden changes in weather. Of over 5,000 larvae placed on trees in the fall, less than 1 per cent survived to June, and most colonies disappeared between January and March. These observations indicate that factors other than parasites and predators were responsible for the heavy winter mortality.

Summary

The silver-spotted tiger moth reached infestation proportions in southwestern coastal British Columbia in 1953. The outbreak increased in intensity until it collapsed suddenly in the southern portion of its range in the spring of 1956. The primary host was Douglas fir, but other conifers were also attacked.

The large moths are brown with distinctive white and cream markings on the wings. The eggs are about 1 millimetre in diameter, are light green with a darker green centre, and are laid on the needles. Field- or insectary-reared larvae may have either seven or eight instars, not necessarily associated with sex, but laboratory-reared larvae have eight instars. Mature larvae have a black head, and the body is covered with brown setae with tufts of black and yellow setae along the dorsal line, and two black lateral tufts on the first and seventh abdominal segments. The cocoons are brown, oval shaped, and well concealed. The pupae are light amber, later turning to brown, with conspicuous black spiracles. The female is larger than the male in all stages.

All stages of the insect are of relatively long duration. The moths emerge from the last half of July to the end of August, and lay an average of 300 eggs, usually on the south or west sides of the tree crowns. The eggs hatch in about a month. The young larvae feed in colonies and spin a loose web. Larvae overwinter in the third, fourth, and fifth instar; they feed during fine weather. Regular feeding is resumed in April. From one to four lateral branches may be

heavily defoliated before the colony breaks up. Larvae may then either scatter throughout the entire crown or leave the tree, or migrate to the tip and defoliate the terminal before scattering. Cocoons are found on the underside of branches, on tree trunks, dead stems, and shrubs. The larvae pupate about a week after spinning cocoons. The pupal stage lasts an average of 45 days.

Although a single colony can cause considerable defoliation, there was no tree mortality. No tree had enough colonies to cause complete defoliation, and heavy spring feeding was on the previous year's foliage. The buds were unharmed and produced a normal complement of foliage.

Parasitism was light and disease was absent. Predators, although causing some mortality, were not considered a controlling factor. It is believed that overwintering mortality, probably caused by adverse weather conditions, was a controlling factor.

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The Olfactory Guidance of Flying Insects

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Introduction

The use of olfactory repellents, especially against biting insects, is an important protective measure. It is also a matter of common knowledge that certain insects are able to locate their mates or their prey largely through the agency of attractive scents. Concerning these latter, Dethier remarks that, "we recognize the fact that no one attractant alone performs the service of guiding an organism to its proper habitat, or mate, or food. The desired end is achieved by a complex array of stimuli working in harmony. In chemical attractants, however, one finds precision guidance. The action of others, as light, temperature, humidity, is comparatively gross, approximating as it does usually, a vicinity. The extreme value of chemical attractants to an organism lies in the specificity and accuracy of operation." (1).

The mechanism whereby the odor guides the insect so precisely to its goal is not known, nor, on reflection, is it self-evident, for olfaction differs from sight and hearing in being a non-directional sense.

It is sometimes supposed that the olfactory detecting apparatus of insects must be almost miraculously sensitive because of the distances over which the attractive odors are known to be effective. It can be shown, however, that the degree of sensitivity need not be much greater than that of Man in order to account for the observed phenomena.

The Calculation of Odor Gradients

Sutton (2) has considered theoretically the diffusion of gases in the lower atmosphere, and his formulae have been used to predict the travel of gas clouds with reasonable success. For the concentration downwind from a continuous point source at ground level, Sutton gives the formula,

$$C_{xyz} = \frac{Q}{\pi C_y C_z \bar{u} x^{2-n}} e^{\left(-x^{n-2}\left(\frac{y^2}{C_y^2} + \frac{z^2}{C_z^2}\right)\right)}$$

where the diffusion coefficients C_y and C_z are,

$$C_y^2 = \frac{4 N^n}{(1-n)(2-n)\bar{u}^n} \cdot g_y^{2(1-n)}$$

$$C_z^2 = \left(\frac{g_z}{g_y}\right)^{2(1-n)} \cdot C_y^2$$

and the other terms are as follows: C_{xyz} is the concentration at a point whose coordinates are x cm downwind, y cm across the wind, and z cm above ground level; Q is the strength of the source, i.e., the rate of emission of gas in grams

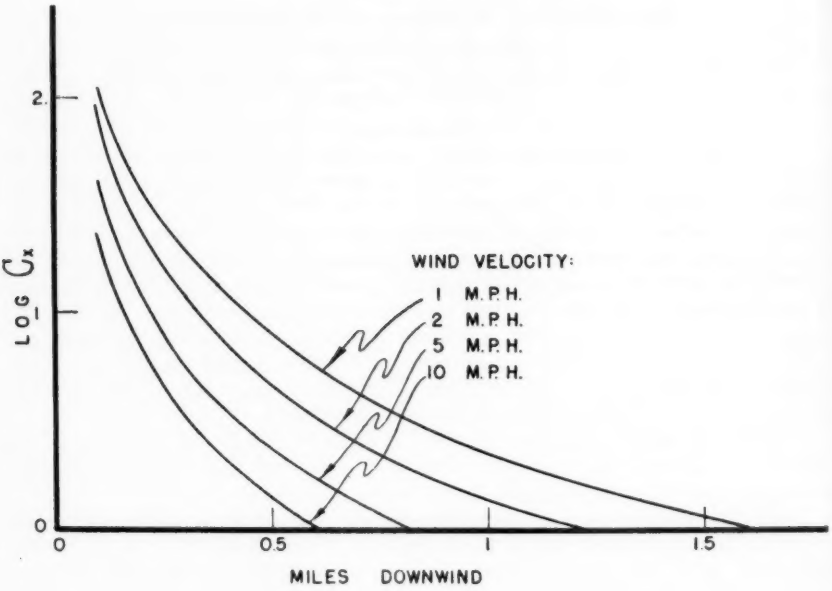

FIGURE 1.

per second; $\bar{u}$ is the mean wind velocity over the layer of atmosphere concerned; g_y and g_z are horizontal and vertical gustiness components; n is an index depending on the vertical wind velocity-profile; N is a quantity called the macroviscosity which depends in part on the roughness of the ground.

Sutton suggests that for average conditions, $n = 0.25$; $g_z = 0.12$; $g_y/g_z = 1.8$; $N = 100$. Using these values for the constants, the concentration of gas from a source of strength 10^{-6} grams per second has been computed for points directly downwind from the source and at ground level, and for mean wind velocities of 1, 2, 5, and 10 miles per hour. The resulting concentrations expressed in units of 10^{-14} grams per liter and converted into their logarithms, are plotted as a function of the distance from the source in Figure 1. If it is assumed that the threshold concentration for perception by the insect is 1×10^{-14} grams of scent per liter of air, then it is apparent that, so far as Sutton's formulae are to be relied upon, the scent will be perceptible to the insect at distances of the order of a mile. Dethier (1) quotes many examples of insects homing on an odor source from distances of this magnitude.

Sensitivity of the Olfactory Apparatus

For a substance with a molecular weight of 100, a concentration of 1×10^{-14} grams per liter means a concentration of 6×10^{7} molecules per liter, or an average of about 60 odorous molecules in each cubic millimeter of air. This is probably fairly near the absolute limit of sensitivity of an insect's olfactory apparatus because it is difficult to conceive of even the most exquisitely designed antennal filter extracting a useful signal from triggering molecules present at a concentration of the odor of 1 per cubic millimeter.

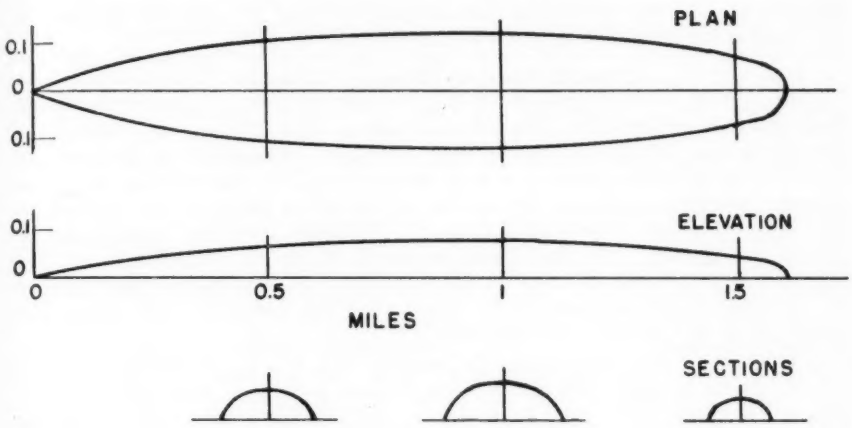

FIGURE 2.

An insect flying at 2 miles per hour covers 88 cm per second, so that if its antennae have a projected area of 2 square millimeters, the total volume of air swept out in 0.01 seconds would be about 18 cubic millimeters. With 60 odorous molecules per cubic millimeter, there would be something of the order of 1,000 available to trigger the nerve impulse. At concentrations much lower than this there would probably not be enough molecules of the odorous substance to initiate a sensory stimulous, though the insect might be able to compensate in part for a lowered concentration by flying faster and so sweeping out a larger volume of air.

A threshold concentration of 1×10^{-14} grams per liter is below that perceptible to the human nose which is reported (3) to be able to detect 0.00000025 micrograms of trinitrobutyl toluene in 50 ml of air, which is 500×10^{-14} grams per liter. We are thus assuming that the insect's detection apparatus is 500 times more sensitive than our own. But it must also be pointed out that Sutton's formulae give the average concentration of gas at each point, while the actual distribution of odor within the cloud at any instant is far from uniform, and zones of relatively high concentration may exist transiently even at the edge of the cloud.

Thus it may be concluded that while the insect's powers of olfaction are remarkable they are not miraculous.

To complete the picture afforded by the application of Sutton's formulae, Figure 2 shows the plan and elevation and three typical cross-sections of the cloud formed in a 1 mile per hour wind by a source of strength 0.000001 gram per second. The "boundary" of the cloud has been arbitrarily taken as the place where the mean concentration falls below 10^{-14} grams per liter, the threshold arbitrarily postulated above. For weaker sources or with less sensitive olfactory organs, the extent of the affected zone would be reduced but its shape would remain very much the same.

In terms of insect guidance, the curves for the lower wind velocities in

Figure 1 are the most significant because insects homing on a distant odor source are likely to be grounded by winds of the order of 10 m.p.h.

The Problem of Olfactory Guidance

In Figure 1, the logarithm of the concentration of odorous material has been plotted because, from the Weber-Fechner Law, this is the most direct measure of the strength of the sensation. Figure 1 suggests that the intensity gradient of the smell sensation is very flat and that over distances of the order of many yards it would be difficult for the insect to perceive any gradient at all. This raises the question of how the "precision guidance" mentioned by Dethier is effected. The insect cannot simply fly up the gradient, i.e., in the direction in which the intensity of the odor increases, because it might have to fly hundreds of feet, possibly in the wrong direction, before it could detect any alteration in the general odor intensity.

It seems to have been generally assumed that the insect merely "flies up wind", which at once raises the question of how the insect while air-borne can know which way the wind is blowing. This problem has been considered with respect to mosquitos by Kennedy (4). He concludes that the insects can maintain an upwind orientation by visual fixation on objects on the ground, provided they fly fairly near the ground. Specifically, he showed that with a wind velocity of 10 cm per second (about 0.25 m.p.h.) Aëdes would have to fly within about 10 cm of the surface and that when well up in the air only strong winds could orient the mosquitos. When they are "very high" (say several meters) the strongest wind could not do so, nor would his method work in darkness or over smooth water. He says, "With regard to the question of host-finding . . . it is maintained here that flying orientation to a wind-borne scent is not, in a direct sense, easily conceivable." And again, "There are no apparent means by which freely flying insects could orient themselves directly to the warmth, moisture, or odor of an air current." He therefore concludes that the primary action of the scent is one of activation, which action if combined with a visual orientation upwind, would serve as an effective host-finding mechanism. This suggestion has been repeated by later writers (5) who speak of a positive anemotaxis released by a scent stimulus.

It may, however, be questioned whether this mechanism would in fact be adequate to effect the precision guidance described by Dethier in the passage cited above. For one thing, the visual control of flight direction relative to the wind requires that the insect keep close to the ground where the wind direction is most likely to vary erratically because of surface irregularities. It would therefore often happen that the insect was carried by vertical air movements too high to orient visually, or that it passed out of the zone of scented air, and unless there is some mechanism to re-orient it on the odor source it will either land and wait for a new stimulation, or fly upwind indefinitely perhaps passing right over the source of the attractive odor.

We must therefore look for some kind of directional structure within an odor-cloud which can produce by itself a reasonably accurate homing reflex in the flying insect. The recognition of such an olfactory guiding mechanism does not rule out the possibility of its effect being reinforced by other senses, such as vision. What must be sought for, however, is a mechanism which can when necessary operate alone (e.g. in the dark or over water) because such a guide will be more economical than one which requires and will not work without the cooperation of two or more senses. If signals from more than one kind of sensory end-organ must be fed into some sort of neural computer in

order to arrive at a useful directive to the motor centres, the all-up weight and bulk of the creature will have to be increased to accommodate the "computer" and this is clearly uneconomic if a single sense can be made to provide the necessary guidance. This does not preclude one guiding mechanism from reinforcing another additively, since an insect must in its time play many parts and so comes equipped to use a variety of sense impressions, and it does not preclude a response being evoked only when two sensations are stimulated simultaneously.

The rather small linear dimensions of an insect together with its relatively simple nervous system would rule out the elaborate organization of sensations which a bird can call on to control and direct its flight. Moreover, the flight of an insect is not purposeful in the way that a bird's flight is purposeful. The insect responds mechanically to a stimulus in a way which will produce a useful result under normal circumstances. The blindly mechanical nature of the response becomes apparent when the stimulus is applied under abnormal circumstances which make the response absurd, as, for example, when a male insect tries to mate with an invisible spot of sex-attractant scent on a sheet of filter paper.

The Structure of the Odor Cloud

Figure 3 shows typical cross-sections of a smoke cloud. These photographs were made by generating an ammonium chloride smoke at floor level in a room in which a constant, slow movement of air was maintained. The room was darkened except for a narrow beam of light which emerged from a slit and illuminated a cross-section of the cloud. The general appearance of the cloud is shown in Figure 4.

Evidently the "mathematical" cloud depicted in Figure 2 represents a long time-average condition and corresponds more to a time-exposure than to an instantaneous photograph. In the actual cloud, the odor is concentrated in a great number of more or less separate filaments or lamellae which writhe and twist as they move downwind away from the source. The mathematical theory of these trails has not been worked out, but they are caused by shearing movement between air masses and are thus constantly re-generated. This accords with the fact shown by observation of smoke-clouds that the filamentary structure persists even at great distances from the source.

It is impossible to conceive of any mechanism by which an insect could back-track along the intricate and rapidly shifting odor trails of the actual cloud. Moreover, an attempt to fly directly up the average odor gradient would be defeated not only by the flatness of that gradient, which has already been referred to, but by an extremely adverse signal-to-noise ratio. Nevertheless, the cloud structure does provide a sign-post which might work somewhat as follows.

A Mechanism of Olfactory Guidance

An insect flying at random and entering a cloud like that shown in Figure 3 would perceive the odor not as a continuous sensation of gradually increasing strength, but rather as a series of pulses or alternations of high and low odor intensity as it passed through the many odor trails that make up the cloud. This effect would be more noticeable to an insect whose olfactory organs are external than it would be to a higher animal whose sensory organ is internal and arranged to sample a relatively large volume of air at each inspiration. On account of the logarithmic relation between the intensity

Fig. 3. Cross sections of a smoke cloud.

Fig. 4. General appearance of a smoke cloud under light wind conditions, showing structure.

of the sensation and the concentration of the odorous material, the "strength" of the smell may not differ much between one streak of high intensity and another. What will vary noticeably, however, is the time interval between one "high" and the next. As the flying insect penetrates further in towards the centre of the cloud, the odor trails will be encountered more frequently, so that while the "highs" or pulses will still be irregular the interval between them will tend to become shorter. This can be made to supply the necessary directional clue in the following way.

While it is in free flight and before it enters the cloud, the insect probably searches by flying a series of rather long, zig-zag paths. If, when it enters the cloud, its tendency to turn is inhibited as long as the interval between pulses tends to decrease, it will be led generally in the right direction, toward the source. If it starts to move out of the cloud or away from the source, the interval between pulses will tend to lengthen and this lengthening could release the inhibition on the tendency to turn. This would cause the insect to abandon its fixed flight path and make a series of short, violent zig-zags until it once more locates a path in which the pulse interval tends to decrease. The following very simple series of signals and responses would enable an insect to home on an odor source with considerable precision:

Signal.	*Response.*
None.	Long zig-zag flight path.
Pulses at decreasing intervals.	Fixed flight path.
Pulses at increasing intervals.	Short zig-zag flight path.

A continuous signal, as in a region where the concentration of odorous material was perfectly uniform, would be equivalent to no signal at all. The absence of any response by the insect under these conditions would ordinarily be attributed to fatigue.

Where sex-attractants are involved, and these are the scents which operate over great distances, the emitting insect, usually the female, could actively assist the guiding process by emitting the scent in a series of short puffs.

Klinokinesis is a well-known type of animal response of which the above mechanism is a special type. In klinokinesis the rate of random turning depends on the intensity of stimulation in such a way that there is an extra tendency to turn aside when the animal is going away from the aggregation zone of a gradient. Thus klinokinesis as ordinarily conceived is similar to the mechanism

proposed here except that it makes use of a change in the intensity of the sensations, whereas the method here suggested employs a change in the interval between sensations. This does not appear to have been previously recognized as a possible guiding signal, but it seems to be the most reasonable in view of the filamentary structure of the odor cloud. The very abrupt transitions between regions of high and low odor intensity would impose a very high background of "noise" on any guidance mechanism which depended on a gradient in the strength of the average odor. Klinokinesis as hitherto conceived would hardly provide a workable means of olfactory guidance because of this very adverse signal-to-noise ratio. The suggested modification avoids that difficulty.

Conclusion

The principal reason for undertaking this enquiry was a consideration of the methods which have been used for ascertaining the insect-attractant or insect-repellent properties of various substances. It seems to have been generally assumed that the insect will somehow perceive: (a) the presence of an odor which may be either attractive or repellent, and, (b) the direction from which the odor is coming. This second piece of information can be deduced fairly easily by a crawling insect, but it is more difficult for an insect in flight.

Any method of screening substances for olfactory attractancy or repellency which requires a directed response from the insect should provide the insect with the sign-posts it needs and would have under natural conditions. In particular, this requires that the insect *not* be exposed to carefully controlled and uniformly disseminated odors. Rather should it be provided with an odor gradient and one, moreover, which does *not* correspond too closely to the mathematically idealized pattern typified by Figure 1. It is, of course, also evident that attractants and repellents for insects which normally fly to their destinations should be tested against insects which are in flight during the tests.

The potential economic importance of properly selected and highly specific attractants is very great. As an alternative to the use of largely undiscriminating poisons, an attractant capable of luring a specific insect species into a trap has very obvious practical advantages. If, as has been suggested elsewhere, olfaction (including insect olfaction) depends on the perception of certain very low-frequency molecular vibrations (6), the way is open to the rational search for very active and specific attractant and repellent substances. While the foregoing relates mainly to guidance by attractive odors, the same sign-post mechanism could guide insects away from the source of a repellent odor. Whether in fact it does so would depend on the actual role of naturally occurring repellent substances, about which not much appears to be known.

Observation of the behaviour of flying insects under conditions as nearly natural as possible should enable the general correctness of the suggestions made here to be assessed. The possibility of combined guidance clues is ever-present, and in particular it may often turn out that the insect is stimulated to flight by the perception of an odor, sets its general course up wind by visual fixation, and is kept from straying out of the odor stream by a variant of klinokinesis such as has been outlined above.

Acknowledgments

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Field Experiments with *Pseudomonas aeruginosa* (Schroeter) Migula to Control Grasshoppers[1]

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This is a report on field trials near Lethbridge, Alberta, in 1954, to determine whether the artificial distribution of the bacterium *Pseudomonas aeruginosa* (Schroeter) Migula would contribute to the biological control of a natural population of grasshoppers. This bacterium was isolated from laboratory-reared grasshoppers, and Bucher and Stephens (1957) showed it to be relatively virulent when experimentally fed to grasshoppers but very susceptible to desiccation. Unpublished information from Miss Stephens indicated that the addition of sucrose (5.0 per cent), casein (1.0 per cent), and gastric mucin (1.0 per cent) to suspensions of *P. aeruginosa* helped to preserve the viability of the bacteria when dried in thin films. Therefore, these substances were incorporated in all formulations used in the field experiments.

Three field trials were conducted. In the first, *P. aeruginosa* was applied in a liquid medium to areas known to contain viable grasshopper eggs; the other two, in a bait on which grasshopper nymphs and adults would feed.

Application to Grasshopper Egg Beds

The application of *P. aeruginosa* to grasshopper egg beds required a liquid medium so that the organisms would infiltrate the soil to the approximate depth of the egg pods and the hatching nymphs would come in contact with the bacterium. A medium consisting of dehydrate Bacto nutrient broth (0.8 per cent), mucin (1.0 per cent), casein (1.0 per cent), sucrose (5.0 per cent), and distilled water was used for culturing and applying the bacteria. The medium was inoculated with *P. aeruginosa*, incubated at 36°C. for 24 hours, and diluted one to 10 with distilled water.

In the laboratory, the diluted culture was applied to soil containing egg pods in incubation for emergence. Eggs treated with sterile distilled water served as controls. Hatched nymphs were placed daily in cages and reared until death. The dead specimens were plated on nutrient agar (Difco) to determine whether *P. aeruginosa* was present. The experiment was not terminated until 14 days had elapsed without any deaths. A total of 130 nymphs hatched from the control and 65 from the treated jars. Of these, 18 (14 per cent) of the controls died without *P. aeruginosa* and six (9 per cent) of the treated died, all with *P. aeruginosa* infection.

In the field, the diluted culture was applied to six square-yard areas at the rate of three litres per square yard. The areas were enclosed with cages of

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plastic screening. Two areas, similarly enclosed to serve as controls, received the same amount of water. Two applications were made, the first on May 24 and the second 14 days later when it was apparent from plated samples of soil from the caged areas that the bacterium had almost completely disappeared. The cages were examined twice daily for grasshopper nymphs. Unfortunately only 11 grasshoppers hatched: seven of *Melanoplus bivittatus* (Say), one of *M. mexicanus* (Sauss.), and three of unidentified species, and all of these came from a single treated area. Six of these 11 specimens died with *P. aeruginosa* infection.

Application in Bait Form

As the bacterium is extremely susceptible to desiccation, no known spray mixture would preserve its viability and infectivity for more than a few hours under the dry field conditions of Western Canada. Therefore the bacterium was applied to nymphal and adult grasshopper populations in a bait that could be readily applied by hand and that would retain moisture and preserve the viability of the bacteria for longer periods. A number of substances were experimented with and tests were made to determine their effect on the survival of *P. aeruginosa* in experimental bait pellets over a 72-hour period. The formulation giving the highest survival of the bacterium in bait pellets consisted of 58.7 grams of bran, 36.7 grams of flour, and 15.0 grams of finely powdered peat in the dry portion and 1.2 grams of dehydrated nutrient broth, 1.5 grams of mucin, 1.5 grams of casein, 7.5 grams of sucrose, and 150 ml. of water in the liquid portion. The liquid portion was prepared, steam-sterilized, inoculated with the bacterium, and incubated at 36°C. for 24 hours to allow bacterial multiplication; it was then thoroughly mixed with the unsterilized dry portion and was then ready for application.

Counts on the freshly prepared bait were in the order of 5×10^9 organisms per gram. As the median lethal dose of *P. aeruginosa* when ingested was calculated to be approximately 10,000 organisms (Bucher and Stephens, 1957), a grasshopper would have to eat only 0.002 mgm. to receive an LD_{50} at the time of application. This quantity was carried on less than one flake of bran.

The field trials were conducted along an unused road allowance near Lethbridge. For each of the two trials, eight plots of 620 square feet were selected. A buffer strip of at least 35 yards was left between plots. The vegetation in the plots was luxuriant and consisted mainly of wild mustard, prickly lettuce, and dandelions.

The grasshopper population varied from 40 to 100 per square yard (visual estimate). The most abundant species was *M. bivittatus*; two other economic species, *M. mexicanus* and *Camnula pellucida* (Scudd.), were also present. The relative numbers of the latter two species increased slightly over the season. During the first trial, all instars from first to fifth were present, the third and fourth being most abundant. During the second trial, all instars but the first were present, the adult being most abundant.

The first trial was begun on June 24. The liquid and dry portions of the bait were mixed together at 6.30 a.m. and applied immediately by hand to six of the eight plots at 10 pounds of dry bran per acre as recommended by Handford and Putnam (1952).

Samples of grasshoppers were collected at random by sweeping from the plots one, two, and 14 days after the bait was applied. Six samples of 100 grasshoppers were taken from each plot, including the two control plots, and were placed in cages. They were examined daily and the dead specimens removed and fresh food (dandelions) supplied.

Death was considered to have been caused by *P. aeruginosa* if the bacterium

was isolated from the dead insects. This was determined by pulling the head off the insect and placing a drop of body fluid on a plate of Sabouraud's maltose agar (Difco). Characteristic green colonies appeared after 24 hours if the bacterium was present.

The second bait application was made on July 27 in the same way. A collection could not be made on the fourteenth day as it was necessary to apply an insecticide to the roadside area as soon as the second collection was completed.

Though some mortality was caused by the bacterium, the amount was insignificant from the standpoint of control. The percentage mortalities per treated plot (600 grasshoppers) in the two trials were as follows:—

	First Day		Second Day		Fourteenth Day	
	Range	Average	Range	Average	Range	Average
First trial	0.2-3	1	0.2-2	1	0	0
Second trial	1-5	3	1-4	1	–	–

There was no mortality caused by *P. aeruginosa* in the control plots.

Because of the low rate of mortlity it was not possible to determine whether certain species or instars are more susceptible than others to *P. aeruginosa* in the field.

Discussion

As the degree of mortality was very low when the bacterium was distributed as a bait, this method cannot be considered practical for biological control. All factors contributing to the low degree of mortality are not known, but the most important probably concern the attractiveness of the bait and the survival of the bacterium in the bait.

Though hatching nymphs were infected by applying the organisms to grasshopper egg beds, the hatch was too low to permit definite conclusions. It may be advisable to try this method again at a time when more satisfactory hatching conditions are predicted.

Summary

Field trials were conducted near Lethbridge, Alberta, in 1954, to determine whether the artificial distribution of the bacterium *Pseudomonas aeruginosa* (Schroeter) Migula would contribute to the biological control of a natural population of grasshoppers.

The bacterium was applied in a liquid medium to grasshopper egg beds and in a bait to grasshopper nymphs and adults. Though some mortality was caused by *P. aeruginosa* resulting from both methods of application, the figures were insignificant from the standpoint of control. Further tests with egg bed treatment may be advisable as the hatch was too low in the test plots to permit definite conclusions.

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Notes on Parathion-Resistant Strains of Two Phytophagous Mites and a Predacious Mite in British Columbia[1]

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The existence of strains of mites resistant to parathion has been well established (Garman, 1950; Lienk, Dean, & Chapman, 1952; Newcomer & Dean, 1952; Smith & Fulton, 1951). Resistant strains of the European red mite, *Metatetranychus ulmi* (Koch), first occurred in orchards of the Pacific northwest in 1950 (Newcomer, 1951; O'Neill & Hantsbarger, 1951), approximately three years after parathion was first used as an acaricide. Two other species of orchard mites, the Pacific mite, *Tetranychus pacificus* McG., and *T. mcdanieli* McG., were subsequently reported to have developed parathion-resistant strains in the same area (Newcomer & Dean, 1953). Though parathion is lethal to most predacious mites and insects, Huffaker and Kennett (1953) found a difference in tolerance between species of *Typhlodromus* in the field and in the laboratory: *T. reticulatus* Oudms. was very susceptible to parathion whereas *T. occidentalis* Nesbitt was not appreciably affected by it.

Parathion was first recommended to British Columbia fruit growers in 1949 (Morgan & Downing, 1950). At that time it gave excellent control of the European red mite; the two-spotted spider mite, *Tetranychus telarius* (L.); the Pacific mite; and the apple rust mite, *Vasates schlechtendali* (Nal.). Growers complained of a lack of control of the two-spotted spider mite as early as 1950. Poor control may have been due either to inadequate spray coverage or to the development of a parathion-resistant strain; however, resistance was not proved. The first definite evidence of a parathion-resistant strain of the European red mite in this area was obtained in 1953 (Downing, 1954), but some growers had not obtained commercial control of the mite with three to four sprays of parathion in 1952. Since then, work in British Columbia has also demonstrated resistance in an eriophyid mite and resistance or tolerance in a predacious mite.

Methods

The results reported below were obtained from experiments on the influence of insecticides on phytophagous mites and their predators. The work was conducted in one commercial and two abandoned apple orchards.

The commercial orchard, at Summerland, B.C., consisted of a block of Yellow Transparent apple trees that had been sprayed in previous years with the recommended insecticides and fungicides. These sprays had practically eliminated the predacious mite species. Phytophagous mites in the orchard were mainly the European red mite, the apple rust mite, and the yellow spider mite, *Eotetranychus carpini borealis* (Ewing). A few of the two-spotted spider mite and the brown mite, *Bryobia arborea* M. & A., were also present.

The two neglected orchards, near Oliver, B.C., had not been sprayed for 10 to 15 years. They were not pruned, fertilized, or irrigated. Sub-irrigation from nearby streams kept the trees alive. In one orchard the trees were mainly Delicious; in the other, Spy, Ben Davis, Newtown, and seedlings occurred. The mite fauna of both orchards was similar, but differed from that of the commercial orchard. The pear leaf blister mite, *Eriophyes pyri* (Pgst.), the brown mite, and the apple rust mite were the predominant phytophagous species. The pear leaf blister mite caused extensive damage to all varieties except Delicious; the

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other two species were not sufficiently numerous to be of economic importance. The principal predacious mites were *Mediolata* sp. and *Typhlodromus* spp.

Beginning in 1951, three sprays of parathion were applied annually for five consecutive years to a block of trees in each orchard. No other insecticide or fungicide was applied during that period. Spray dates, about June 1 and 20 and August 1, coincided with the recommended dates for codling moth spray applications. On each date, a wettable powder containing 15 per cent parathion was applied at one pound per 100 gallons of water. In each orchard, adjacent non-sprayed trees were used as a check. In the commercial orchard, the European red mite populations in the check and parathion plots were compared with those in a DDT plot. The DDT plot was sprayed with 50 per cent DDT wettable powder at 1.5 pounds per 100 gallons of water on the same dates as the parathion applications. All sprays were applied with a high-volume, hand-gun sprayer operated at a pump pressure of 450 to 500 p.s.i.

As a rule, ten trees were sampled in each of the check plots, six in the parathion plots, and six in the DDT plot. The mite populations were estimated at intervals throughout the summer by counting the mites on 20 leaves picked at random from one quadrant of each tree. The mites were removed from the leaves by a mite brushing machine and counted under a low-power, wide-field stereoscopic microscope (Henderson & McBurnie, 1943; Morgan *et al.*, 1955). The mite counts were transformed to log $(n + \frac{3}{8})$ and tested by analysis of variance for differences at the five per cent level of significance (Freeman & Hall, 1955).

Results and Discussion

In the commercial orchard, parathion practically eliminated all aphids and leafhoppers. Despite the eventual occurrence of extremely large numbers of the European red mite and the apple rust mite in this plot, the trees had greater terminal growth and the leaves were of darker green than in adjacent blocks of non-sprayed and DDT-sprayed trees. Similar results were obtained in the neglected orchards with respect to insect control and increased vigour of trees. In addition, the summer applications of parathion markedly reduced the numbers of the blister mite and controlled the brown mite. In these orchards, the apple rust mite was the only phytophagous mite that eventually developed a parathion-resistant strain.

In the three orchards, parathion killed all predacious mites except *T. occidentalis*. However, in 1954 and 1955, a few of *Mediolata* sp. were found in the parathion-sprayed trees in the commercial orchard.

European Red Mite

On the basis of samples of foliage taken five times in 1951, six times in 1952, three times in 1953, four times in 1954, and eight times in 1955, the average numbers per leaf of the European red mite in each of the three plots of the commercial orchard were:—

	1951	1952	1953	1954	1955
Parathion	1	50	12	82	300
DDT	18	68	20	43	257
Non-sprayed	14	20	22	10	17

The ratio necessary for significance between treatments at the 5 per cent level was 1.62:1.

The above results show that in 1951, the first year of the experiment, three sprays of parathion gave excellent control. The presence of strains of mites resistant to parathion first became apparent in 1952. The first cover spray, applied on May 27, gave good control. Three weeks later, the average number

of European red mites was less than one per leaf, whereas on the DDT and check plots the numbers were 19.0 and 3.3 respectively. The second parathion spray, applied on June 24, gave no apparent control; by July 21 the average numbers of mites per leaf on the parathion, DDT, and check plots were 284.7, 374.5, and 106.8 respectively. Thus a parathion-resistant strain of the European red mite developed in this orchard after the application of six sprays, one of which was applied by the grower in 1950, three by the authors in 1951, and two by the authors in 1952. On this basis, parathion-resistant mites could be expected in a commercial orchard within three years if two sprays of parathion were applied annually. Some growers did report a lack of control of the European red mite from parathion in 1952, three years after parathion was first officially recommended.

No significant change in resistance to parathion occurred in 1953. However, abnormally large numbers of winter eggs of the European red mite were deposited in the plot sprayed with parathion. The abundance of mites in the spring of 1954 indicated the relative numbers of winter eggs laid the previous year; for example, on May 28, 1954, the average numbers of mites per leaf were: parathion, 65.0; DDT, 1.9; and check, 0.5.

To determine the effects of the third cover spray on the degree of resistance developed in the European red mite, that spray was omitted from the schedule on two trees in the parathion plot after 1952. In the fall of 1953, more winter eggs were deposited on the trees that received the third spray than on the trees sprayed twice. This difference was reflected in May, 1954, when there were 24 times more mites on the trees sprayed three times than on those sprayed twice. In 1954 and 1955, the average numbers of mites per leaf on the trees treated annually with three sprays of parathion were 83 and 187 respectively; the numbers on the trees treated with two sprays were 29 and 24, and on non-sprayed trees 10 and 11.

During the summers of 1954 and 1955, parathion gave no control of the European red mite. This effect can be definitely attributed to parathion and not to an interaction of spray materials, as parathion was the only material applied to the trees for a period of five years. The larger populations of the European red mite on the parathion-sprayed trees cannot be attributed to the lack of predation by the typhlodromids as the numbers of these predators were often greater on the parathion plot than on the non-sprayed trees (Table II). Also, as the numbers of the European red mite on the parathion plot were as large as or larger than those on trees sprayed with DDT it must be concluded that parathion was obviously giving no chemical control and that it was possibly promoting the development of this phytophagous mite. Parathion had three different effects on the European red mite during the five year period: good control by initial treatments; gradual development of a resistant strain; and, finally, an apparent stimulatory effect.

Apple Rust Mite

The rate of development of strains of the apple rust mite resistant to parathion (Table I) paralleled that of the European red mite. This occurred not only in the commercial orchard treated previously with such spray materials as DDT, lime-sulphur, nicotine sulphate, and one spray of parathion, but also in the two neglected orchards where no sprays had been applied for a number of years.

In 1951, parathion gave good control of the apple rust mite in the commercial and in one neglected orchard, but only fair control in the other neglected orchard. Evidence of parathion-resistant mites occurred in the three orchards in 1952

TABLE I

Average numbers per leaf of the apple rust mite on apples trees treated annually with three sprays of parathion and on non-sprayed trees in one commercial and two neglected orchards, 1951–1955*

Orchard	Plot	1951	1952	1953	1954	1955
Commercial	Parathion	9	461	60	275	278
	Non-sprayed	270	413	40	331	404
Neglected	Parathion	0	67	178	128	159
	Non-sprayed	3	22	24	30	38
Neglected	Parathion	13	125	303	123	153
	Non-sprayed	42	124	35	136	90

*Plots sampled an average of five times annually: 120 to 200 leaves per plot examined each time. Ratio necessary for significance between treatments at 5% level, 1.61:1.

between the second and third cover sprays. After the third application, the numbers of the apple rust mite increased rapidly. These late-season populations were largely responsible for the increased averages in the parathion plots of that year.

***Typhlodromus occidentalis* Nesbitt**

No typhlodromids were present in the commercial orchard in the spring of 1951, because the trees had been sprayed in previous years with insecticide such as DDT. A few were encountered in the check plot at the end of June, and by September these predators had increased to an average of over one per leaf. Only two typhlodromids were found on the 600 leaves sampled from the parathion plot in 1951; they were collected during September, about one month after the last cover spray was applied.

The first cover spray of parathion applied in the neglected orchards in 1951 drastically reduced the numbers of *Typhlodromus* spp. and the second cover spray eliminated them. In one of these orchards no typhlodromids were found throughout the rest of the season. In the other, four specimens were present on the 120 leaves sampled early in October, about two months after the application of the third cover spray.

The immediate effects of parathion applied in 1952 were similar to those of 1951. However, within a few weeks after the application of the third cover spray, the number of typhlodromids began to increase rapidly. By September, the number of predacious mites in the parathion plot of the commercial orchard was almost five per leaf, and in one neglected orchard there were more typhlodromids in this plot than in the non-sprayed plot. The increase of these mites late in the season of 1952 did not establish the presence of a strain resistant or tolerant to parathion, but only indicated that the residual effect of parathion was short-lived. The relatively large numbers of typhlodromids may have been associated with the increased numbers of the apple rust mite, which by that time was evidently developing a parathion-resistant strain. In 1953, typhlodromids were present throughout the season in the parathion plots of the three experimental orchards. That year they became more numerous during July after the application of the second cover spray. In 1954 and 1955, the numbers of typhlodromids on the parathion plots continued, with one exception, as great as or greater than those on the check plots.

TABLE II

Average numbers of *Typhlodromus occidentalis* Nesbitt per 100 leaves on apple trees treated annually with three sprays of parathion and of *Typhlodromus* spp. on non-sprayed trees in one commercial and two neglected orchards, 1951–1955*

Orchard	Plot	1951	1952	1953	1954	1955
Commercial	Parathion	0.4	128	32	38	250
	Non-sprayed	65	545	11	6	74
Neglected	Parathion	3	13	59	88	51
	Non-sprayed	43	29	36	34	41
Neglected	Parathion	2	29	39	150	40
	Non-sprayed	120	73	33	74	175

*Plots sampled an average of five times annually: 120 to 200 leaves per plot examined each time. Ratio necessary for significance between treatments at 5% level, 1.68:1.

Collections were first made in 1953 to identify the species of *Typhlodromus* resistant or tolerant to parathion. Identifications were based on the key of Cunliffe and Baker (1953). The species complex differed in the three orchards; *T. occidentalis* was the only species present in the non-sprayed plot of the commercial orchard; *T. rhenanus* (Oudemans) was most abundant and *T. occidentalis* and *T. conspicuus* (Garman) occurred occasionally in the check plot of one neglected orchard; an unnamed species of *Typhlodromus* (Cunliffe & Baker, 1953) and *T. occidentalis* were present in the approximate ratio of 50 to one in the check plot of the other neglected orchard. Of 400 specimens identified from the parathion-sprayed plots from 1953 to 1955, all but five were of *T. occidentalis*. Presumably parathion was lethal to all typhlodromid species in the orchard except *T. occidentalis*. Whether this species is inherently less susceptible to parathion than the other typhlodromids or whether a parathion-resistant strain evolved as a result of spraying was not established.

The degree of parathion tolerance was investigated in one of the neglected orchards in 1954 and in the commercial orchard in 1955. Two trees in the parathion plots of both orchards did not receive a third cover spray. The numbers of *T. occidentalis* on these trees were compared with those on the sprayed trees before and after the treatment. Samples taken one week after spraying indicated that, in the neglected orchard, the third parathion treatment killed 60.4 per cent of the mites in 1954; in 1955, 43 per cent were killed by parathion in the commercial orchard. Three weeks after treatment the numbers of *T. occidentalis* on the sprayed trees had increased to about the same level as on the non-sprayed trees. In laboratory experiments, Huffaker and Kennett (1953) found that 37 per cent of the *T. occidentalis* were killed when they were exposed for 24 hours to a dust containing two per cent parathion; the remainder were naturally tolerant to parathion.

It was not demonstrated whether strains of *T. occidentalis* resistant or tolerant to parathion had developed in growers' apple orchards, because DDT, which is widely used for the control of the codling moth, had killed practically all predacious mites. However, proof of the occurrence of such strains under commercial orchard conditions was obtained from a prune block where the grower had seldom, if ever, used DDT, but had applied at least one spray of parathion annually for approximately seven years. About one week after the last spray was applied in August, 1955, the numbers of *T. occidentalis* averaged

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196 per 100 leaves. These predators were found in association with parathion-resistant strains of the European red mite and the apple rust mite, which were present in such numbers that the foliage was becoming severely bronzed.

Summary

In three apple orchards in the Okanagan Valley of British Columbia that received three sprays of parathion annually from 1951 to 1955, the European red mite, *Metatetranychus ulmi* (Koch), and the apple rust mite, *Vasates schlechtendali* (Nal.), developed strains resistant to parathion within two years. In 1954 and 1955, the European red mite was more numerous in the parathion-sprayed trees than in trees treated with a similar number of DDT sprays. More winter eggs were deposited on parathion-sprayed trees than on DDT-sprayed or non-sprayed trees.

Parathion practically eliminated *Typhlodromus* spp. until late in the summer of 1952, when relatively large numbers of *T. occidentalis* Nesbitt occurred a few weeks after the last spray was applied. From 1953 to 1955, the numbers of *T. occidentalis* on parathion-sprayed trees were usually as great as or greater than those of *Typhlodromus* spp. on non-sprayed trees. It is not known whether *T. occidentalis* is inherently tolerant of parathion or whether a resistant strain evolved as a result of exposure to this acaricide.

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Parasitic Flies of the Genus Mochlosoma (Tachinidae, Diptera)[1]

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Members of the present genus are commonly encountered in faunistic studies of the southwestern United States and Mexico, but little or no information has been recorded concerning their biology or host relationships and taxonomic status.

Brauer and Bergenstamm established *Mochlosoma* with *validum*, new, as the type and sole original species, (Zweifl. d. Kaiserl. Mus., IV, 1889, 126). The type series is in the Vienna Natural History Museum, and apparently it was not seen by any American worker in Diptera until 1925, when Aldrich recharacterized the genotype and restricted the type series to the single male specimen from Pennsylvania, (Ann. Ent. Soc. Amer., XVIII, 116-118). More recently Townsend also redefined the genus (Manual of Myiology, part VII, 1938, 346-347). These interpretations of the generic characters are now generally accepted for *Mochlosoma* and are summarized for ready reference to all species included in the accompanying key.

Most of the material here under consideration was received for identification from various collectors mentioned below; to whom my thanks are due for the privilege of including all pertinent materials. I am also indebted to Curtis W. Sabrosky for the loan of material in the U.S. National Museum, including a series of specimens which was compared with the genotype by the late Dr. J. M. Aldrich. Types of new species deposited in the U.S. National Museum and the Kansas University Museum are cited in each case under the following specific descriptions.

Excepting the uncommonly long slender proboscis, *Mochlosoma* approximates the general habitus of *Ptilodexia* (of authors). Among other allied prosenine genera, *Prosena* and *Prosenoides* possess a similar type of proboscis but differ in having a much higher or stronger facial carina which narrowly separates the bases of the antennae; the latter approximate the length of face, and the vibrissae are situated near the oral margin. Also, it may be pointed out that the palpi in *Prosena* are much shorter than the antennae and that the propleura are distinctly haired in *Prosenoides*.

Generic characters of *Mochlosoma*.—The species included here may be characterized in common as follows: Length 9 to 16 mm. Head nearly as wide as high; frontal profile well sloped and about one-third longer than facial; antennal axis well below eye middle and a trifle longer than vibrissal; clypeus depressed on sides, low median carina transversely rounded on crest and gradually flattened below mid face; facialia practically bare; epistoma one-third to one-half as long as wide, moderately bowed forward from clypeal plane; vibrissae ranging from length of second to the combined length of second and third antennal segments above oral margin; parafacialia inconspicuously setose to distinctly haired; antennae usually not reaching below mid face, third segment barely longer than second; arista plumose to tip, proximal segments short; vertex one-tenth (male) to one-third (female) of head width; male without verticals and orbitals but usually with one or more secondary pairs of long proclinate ocellars; proboscis long and slender usually reaching well beyond base of venter, labella very slender; palpi subcylindrical and stoutish, about equal to length of antennae; eye bare, extending almost to vibrissal level; cheek one-third to one-half or more of eye length; occiput somewhat bulged or inflated on lower part behind cheeks.

[1]Contribution No. 2714, from the Department of Entomology, Texas Agricultural Experiment Station.

Thoracic chaetotaxy variable as follows: Acrostichal 2, 3 (sometimes 3, 3 or 3, 4); dorsocentral 3, 4 (sometimes 3, 3); intraalar 3; supraalar 3; presutural 1 (outer); humeral 5-7; posthumeral 2 or 3; notopleural 2 or 3; postalar 2; sternopleural 3; pteropleural 2-5 (smaller than sternopleural); scutellum with 2 or 3 lateral, 1 weaker decussate apical and usually 2 appressed discal pairs; prosternum and propleura bare; postnotal slopes setose. Legs long but not very slender; male claws greatly elongated, in female shorter than apical tarsal segment. Wing large reaching well beyond tip of abdomen; first vein bare, third with two to six setulae near base; first posterior cell open before wing tip; cubitulus obtuse to rectangular, without stump or fold, about one-fourth wing width from hind margin; last section of fifth vein usually under one-half length of hind cross vein. Abdomen rather sharply tapered towards tip in male but less so and wider basally in female; intermediate segments each with one to three pairs of median discals besides one or two pairs of median marginals on second segment and a marginal row on third; anal segment with a marginal and one to three discal rows above; sternites covered; male genitalia largely retracted in repose; fused forceps rather small, tapering distally to an acute tip; accessory process large and platelike, convex on outer surface, which is finely punctate and bears a dense vestiture of rather short hairs along posterior margin; penis stalk flattened basally, simple in structure, jointed near proximal third and again beyond middle, distal segment tubular terminating in a slightly reflexed pale membranous tip; fifth sternite with a deep median V-shaped excision; female genitalia telescopically retracted, with blunt tipped apical segment soft or fleshly in texture.

Key to Species *Mochlosoma*

1. Abdomen predominantly reddish or yellow, a dark dorsal median vitta may be present 14
   Abdomen entirely black or at most with sides obscurely reddish 2
2. Post dorsocentral bristles four or spaced for four 6
   Post dorsocentrals three 3
3. Haustellum slender and bristlelike 5
   Haustellum stouter, slightly bicurved and non-bristlelike 4
4. Cheek three-fifths eye length; anterior spiracle fringed with yellow hairs; average-sized species moderately robust in build, female (Mexico) ..... *duplare*, n. sp.
   Cheek narrower; anterior spiracle brown to blackish; smaller than average and slender in build, male only (Mexico) ..... *serotinum*, n. sp.
5. Parafacials black-haired to cheek grooves; scutellum reddish apically; haustellum twice head height; tibia black with a pale median ring (Mexico) ..... *demissum*, n. sp.
   Parafacial vestiture sparser, less extensive and often intermixed with pale hairs; scutellum black; haustellum shorter; tibiae wholly reddish yellow (Western U.S.) *illocale*, n. sp.
6. Palpi slender or but slightly thickened apically 7
   Palpi strikingly enlarged apically, nearly one-third as wide as long; haustellum-labellum length subequal to twice head height; anterior thoracic spiracle yellow-fringed; cheek over one-half eye length, female only (Mexico) ..... *sarcinale*, n. sp.
7. Legs except tibiae wholly black 9
   Legs except tarsi wholly red 8
8. Scutellum, posterior calli, sides of mesonotum and humeri pale reddish in ground color; haustellum one and one-half times head height; parafacials sparsely pale-setose above; palpi stoutish; epaulets pale or reddish, female only (Mexico) *rufipes* Coq.
   Scutellum and mesonotum including humeri entirely black; haustellum shorter barely one-fifth longer than head height, but slender and bristlelike; parafacials sparsely black-haired above; palpi very slender; epaulets black (California) ..... *indutile*, n. sp.
9. Calypters white to tawny 12
   Calypters black 10

10. Abdomen wholly black in ground color 11
Abdomen with a deep reddish tinge in ground color at sides, entire upper surface devoid of pale pollen and shiny; anterior thoracic spiracle fringe orange yellow; scutellum and humeri reddish, male only (Mexico) ..... *adustum*, n. sp.

11. Anterior thoracic spiracle deep brown to black; abdomen without any pale pollen on opaque upper surface; thorax and scutellum wholly black, lightly dusted with gray pollen; frontalia complete to triangle, male only (Mexico) ..... *furtum*, n. sp.
Anterior thoracic spiracle fringed with bright yellow to golden hairs; apical abdominal segment conspicuously pale pollinose and contrasting sharply from preceding segment in dorsal view; male frontalia pinched out before triangle (Mexico) *anale* (G.T.)

12. Parafacial vestiture short, scanty and inconspicuous 13
Parafacials distinctly black-haired; haustellum long, slender and bristlelike; calypters semitransparent whitish; abdomen wholly gray pollinose above; male front pinched out before triangle (Canada, U.S., Mexico) ..... *validum* B. & B.

13. Haustellum slightly bicurved and non-bristlelike; parafacial setae black; scutellum and abdomen black, latter entirely gray pollinose above; wings hyaline with a slight but rather uniform yellowish tinge on costal half; frontalia pinched out before triangle, male only (Mexico) ..... *serotinum*, n. sp.
Haustellum slender and bristlelike; parafacial setae pale or whitish; abdomen black, lightly dusted above with whitish pollen to middle of third segment thence shiny to tip; wings yellow costobasally; male frontalia complete to triangle (Mexico) *mexicanum* Macqt.

14. Post dorsocentral bristles four 15
Post dorsocentrals normally three; parafacials sparsely black setose; haustellum stouter than usual and non-bristlelike, averaging about one-fifth longer than head height; thorax black dusted with rather dense gray pollen above, scutellum reddish becoming darker basally (Arizona, Mexico) ..... *duplare*, n. sp.

15. Calypters white, tawny to pale brown 16
Calypters black; abdomen devoid of any pale pollen above; haustellum-labellum length fully twice head height; parafacials black-haired ..... *adustum*, n. sp.

16. Parafacial vestiture black or largely so 18
Parafacial vestiture entirely pale or whitish 17

17. Pronotum with dense opaque subgolden pollen; male eyes subcontiguous above mid front, with noticeably enlarged facets on upper half or more, frontalia pinched out well before triangle; cheeks one-third (male) to three-fifths (female) eye length (Mexico) ..... *sabroskyi*, n. sp.
Pronotum with heavy lusterless pale yellowish gray pollen; male eyes well separated above mide front, facets not noticeably enlarged, frontalia complete to triangle; cheeks one-half (male) to two-thirds (female) eye length (Mexico) *lacertosum* (vdW.)

18. Haustellum slender and bristlelike 19
Haustellum stouter, shorter and slightly bicurved; abdomen reddish on sides with a dark median vitta; fringe of anterior thoracic spiracle deep brown; parafacials pale yellowish gray, black-haired to cheek grooves ..... *duplare*, n. sp.

19. Abdomen distinctly pollinose above 20
Abdomen translucent and shiny at most with thin yellowish white pollen visible in a flat rear view; pronotum lightly dusted with grayish pollen on dark background tinged with red laterally; calypters tawny to brownish; epaulets red (Mexico) *russulum*, n. sp.

20. Mesonotum, humeri and pleura wholly black, scutellum paler in ground color; antennae orange red; abdominal pollen pale yellow to sub-golden; legs black tibiae, apices of femora and trochanters reddish yellow; parafacial vestiture entirely black (Mexico) ..... *laudatum*, n. sp.
Mesonotum with prescutellar area and lateral margins including humeri, upper part of pleura and scutellum red in ground color; parafacials sparsely beset with short intermixed pale and black hairs; third antennal segment infuscated on apical half or more; abdominal pollen pale cinereous to bluish white; legs except tarsi red and dusted with pale pollen (Arizona, Mexico) ..... *opipare*, n. sp.

Mochlosoma duplare, n. sp.

In this species the structure of the haustellum is stouter, slightly bicurved and obviously less bristlelike than in most allied forms. The number of post

dorsocentrals is subject to some variation, normally only three bristles are present. Also, the female abdomen and scutellum are often entirely black.

Male and female.—Head pollen yellowish gray on dark background, broad cheek groove red; parafacial sparsely black-haired; third antennal segment blackish on apical half or more, almost one-half longer than second; male frontalia greatly narrowed upwards but complete to ocellar triangle; palpus yellow, slightly enlarged at apex which bears two or three short black hairs; cheek width about one-half eye length; thorax gray pollinose, marked with four narrow black vittae above; scutellum reddish on apical half or more; wing subhyaline tinged with yellow basally and less distinctly so along longitudinal veins; calypter subopaque, pale tawny; abdomen broadly reddish on sides in male, with a more or less defined median dorsal vitta; fused male genital forceps reddish, clothed behind with an intermixed vestiture of pale pubescence and black pile; distal articulation of penis shortly before apex of same; fifth sternite lobes reddish, beset with a moderate vestiture of black hairs.

Length, 8-13.5 mm.

Holotype male and allotype female, Cuernavaca, Mexico, July 25, 1947, (F. A. Cowan, & M. R. Wheeler). Paratypes: 20 males, same data as type; 1 female, Graham Mts. Wet Cn., Ariz., July 8, 1955, (Butler-Werner); 1 female, Patagonia Mts., Ariz., May 21, 1955, (G. D. Butler); 1 male, Madera Canyon, Santa Cruz Co., Ariz., August 21-26, 1954, (W. A. McDonald); and 1 pair from Mexico, "6 mi. N. E. Jalastitlan, VII-19, 1954, 6,000 ft. and Ixtapan, VIII-9, 1954, 5,500 ft. Univ. Kans. Mex. Expedition" in the Snow Collection, University of Kansas.

The material listed above includes ten females in which the abdomen is wholly black in ground color. These bear the same data and evidently were taken in company with the remainder of the series in which the sides of the abdomen are distinctly red. There appear to be no other important distinctions. Until corresponding specimens of the opposite sex are brought to light, it appears expedient to provisionally consider this color variation as falling within the specific limits of the present form.

***Mochlosoma serotinum*, n. sp.**

A black-bodied gray pollinose species, with the haustellum stouter and shorter than usual, about as described under *duplare*, from which it differs chiefly in the smaller more slender build, wholly black scutellum and abdomen, nearly bare parafacials, etc.

Male only.—Head pollen silvery in dorsal aspect but with a perceptible yellowish tint in most other views; antenna red to arista thence black to tip, third segment slender, clothed with pale pubescence; frontalia reddish, completely pinched out before triangle; cheek width about one-half eye length; usually three dorsocentral bristles but sometimes spaced for four; anterior spiracle infuscated; wing with a slight yellowish tinge on costal half becoming grayish behind; calypter subopaque, pale yellow; epaulet black; abdomen slender, barely as wide as thorax; hypopygium rather small and retracted in repose; distal segment of penis at most one-fifth length of preceding; fifth sternite lobes well exposed, beset with black hairs.

Length, 8.5-9.5 mm.

Holotype: Cuernavaca, Mexico, July 25, 1947, (F. A. Cowan, & M. R. Wheeler). Paratypes: 4 males, same data as type.

***Mochlosoma demissum*, n. sp.**

Smaller and more slender in build than most allied species, from which it

is at once distinguished by the elongated and usually bowed haustellum. Other differences are listed below.

Male.—Eyes well separated before triangle and frontalia complete to latter; vertex 0.15 of head width; head pollen subsilvery to silvery on parafrontal and parafacial; latter black-haired to cheek grooves and subequal clypeal width; third antennal segment black on apical half or more; palpus red to brownish. Thorax black, scutellum more or less reddish, pronotum moderately shining but with distinct grayish pollen which is marked with four vittae behind and five in front of suture. Legs largely black, tibiae with a narrow median yellowish ring; claws and pulvilli elongated and infuscated. Wings subhyaline with a rather uniform tawny gray tinge; calypter pale yellowish white; epaulet black, subepaulet brown. Abdomen entirely black; intermediate segments each with two pairs of discals and long erect hairs above; hypopygium small and retracted, wholly black, platelike accessory process smoother and highly polished distally; lobes of fifth sternite thickly clothed with black hairs which become bristly towards apical margin.

Female.—Grayer than male in general aspect; front at vertex 0.28 of head width; frontalia wider than parafrontal on entire length; two proclinate orbitals set well above mid front; outer verticals scarcely differentiated; thoracic pollen opaque gray; claws and pulvilli short; abdomen wider than in male; segments two and three each with one pair of median discals; hairs on entire upper surface short and appressed; genitalia retracted within tip of abdomen.

Length, 8.5-10 mm.

Holotype male and allotype female, Rio Frio, Mexico, September 9, 1947, (F. A. Cowan, M. R. Wheeler). Paratypes: 2 males, same data as type except one dated September 3, 1947, and 1 male, Paso de Cortes, Mexico City, Mexico, August 31, 1947, (W. G. Downs).

***Mochlosoma illocale*, n. sp.**

A little more robust in build than *demissum* from which it differs in few essential details.

Male.—Frontalia completely pinched out before triangle, vertex 0.13 of head width; parafacial about one and one-half times clypeal width, with short fine hairs restricted to upper half; haustellum straight and bristlelike, one and one-half times head height; cheek subequal to one-half eye length; thorax and scutellum wholly black dusted with opaque gray pollen, notal vittae poorly defined; tibiae wholly reddish, remainder of legs predominantly black; epaulet infuscated, subepaulet yellow; abdomen with opaque tawny gray pollen above becoming paler or bluish white on venter; genital forceps small, tapering to a subacute slightly recurved tip; accessory process moderately shining; finely setiferously punctate on convex outer face; lobes of fifth sternite clothed with a moderately dense vestiture of fine black hairs.

Female.—Outer verticals over half as long as inner; vertex 0.34 of head width; cheek well over one-half eye length; abdominal pollen bluish gray above, with one or two median discals on intermediate segments; tarsal claws reddish basally tips brown, about two-thirds length of apical tarsal segment.

Length, 9-11.5 mm.

Holotype male, Antelope Mt., Grant Co., Oregon, 5,000 ft., August 6, 1932 (D. K. Frewing) and allotype female, Bly, Klamath Co., Oregon, October 13, 1943 (R. E. Rieder). Paratypes: Oregon; 1 male, same data as holotype and 1 male without precise locality, July 9, 1932. Washington; 1 pair Bead Lk., Newport, August 9, 1922 (W. C. Lane). British Columbia; 1 pair Revelstoke Mt., 6,000 ft., August 12, 1923 (E. R. Buckell). California; 2 females, "Los

Angeles Co., September (Coquillett)" and 1 male, "Tahoe Lk., August 14, 1930". Wyoming; 1 male, Signal Mt., August 3, 1947 (F. A. Cowan & M. R. Wheeler). Montana; 3 males, Popular, July 26, 1947 (F. A. Cowan & M. R. Wheeler). Utah; 5 females, Nephi, October 6, 1956 (G. F. Knowlton). New Mexico; 2 females Embudo, September 25, 1897 (Cockerell). Ohio, Amherst, August 27, 1930 (H. J. Reinhard).

Mochlosoma validum Brauer & Bergenstamm

Mochlosoma validum Brauer & Bergenstamm, 1889, Zweifl. d. Kaiserl. Mus., 4:126. Coquillett, 1910, Proc. U.S.N.M., 37:570. Aldrich, 1925, Ann. Ent. Soc. Am., 18:116-118. Townsend, 1938, Manual of Myiology, pt. 7, 346-347.

Prosena valida (Brauer & Bergenstamm) van der Wulp, 1891, Biol. Cent. Am., Dipt. 2:216-217. Aldrich, 1905, Cat. N. A. Dipt., 497.

The salient characters of *validum* are contained in the accompanying key and most other details are listed in the aforecited references, which are readily accessible. The limited material available for this study, which includes only twenty-one specimens (two compared with type), exhibits considerable variation in length of proboscis and ground color of the abdomen. The proboscis always extends beyond the base of the abdomen and sometimes may reach to or even beyond the mid venter. The type specimen has the abdomen broadly reddish along the sides with a dark median vitta tapering rearward according to Aldrich (op. cit.). In the material before me the abdomen is predominantly black in ground color with a more or less distinct reddish tinge at sides in most specimens leaving a vague dark median vitta visable when viewed in a favorable light.

Male and female.—Parafrontal gray to subsilvery pollinose; frontalia red, pinched out before triangle in male, but wider than parafrontal in female; vertex 0.12 (male) to 0.33 (female) of head width; antenna red, third segment darker or brownish beyond arista; parafacial grayish pollinose and distinctly black-haired to broad red cheek groove; palpus yellow; cheek about one-half eye length. Thorax and scutellum black, thinly gray pollinose, dorsal vittae indistinct behind suture; four post dorsocentral bristles. Legs black tibiae and apices of femora reddish yellow. Wing hyaline tinged with yellow basally; veins including costa yellow; costal spine vestigial; epaulet black and subepaulet reddish; calypter large, opaque white to slightly tawny. Abdominal chaetotaxy and genitalia as previously mentioned under summary of generic characters.

Length, 10-14 mm.

The species is widespread in North America, ranging from Pennsylvania (type locality) and New York to British Columbia, Washington State and California thence southward into Mexico.

Mochlosoma sarcinale, n. sp.

Differs from allied forms principally by the characters listed in the aforegoing key. Other minor differences may be noted as follows:

Female only.—Front nearly equibroad on upper half, vertex 0.35 of head width; parafrontal and parafacial gray, broad cheek groove red with thinner pollen; outer vertical half as long as inner; palpus red, broader and longer than antenna; frontalia red, much wider than one parafrontal, extending to vertex on either side of triangle; thorax and scutellum black with rather heavy gray pollen which shows four or five dark vittae on notum in a favourable angle; calypter whitish, slightly broader than long; tibiae yellow, femora reddish apically, tarsi black and quite slender; claws reddish basally, about two-thirds as long as preceding tarsal segment; abdomen with gray pollen in a tessellated pattern when

viewed from above; genitalia retracted within narrowly truncated apex; hairs on entire upper surface appressed.

Length, 8.5 mm.

Holotype: Sierra Madre, Chihuahua, Mexico, August 25 (C. H. T. Townsend) in the U.S. National Museum.

***Mochlosoma rufipes* Coquillett**

Mochlosoma rufipes Coquillett, 1902, Can. Ent., 34:202.

The items listed in the description cited above appear adequate to distinguish the species from all other members of the genus hitherto described. In the material available for study, the predominantly red legs are matched only in the following species, which differs mainly in having a shorter haustellum, wholly black thorax and scutellum; sparser black parafacial hairs, etc.

Female only.—Front at vertex 0.30 of head width, gradually diverging downward into facial angle; parafrontal and parafacial densely gray pollinose, cheek more thinly so on red ground color; antenna short, wholly red, third segment hardly longer than second; one or two frontal bristles below antennal base; two verticals and two strong proclinate orbitals; parafacial sparsely clothed with pale hairs above middle; palpus yellow, stoutish, equibroad from base to apex; cheek in profile one-half eye length; haustellum slender and bristlelike about one and one-half times head height; thorax black, scutellum, posterior calli sides of mesonotum and humeri red; anterior spiracle orange yellow; epaulet pale or reddish; legs red and except tarsi which are contrasting black; reddish claws black-tipped and exceeding one-half length of apical tarsal segment.

Length, 13 mm.

Redescribed from one female labeled, "Sierra Madre, Chih., Mex., Hd. R. Piedras Verdes, 9.7 Coll. Townsend 1784". This is the type locality of the species, and the present specimen (somewhat discolored) is evidently one of the eight females originally listed as comprising the type series, Catalogue No. 6301, U.S. National Museum.

***Mochlosoma indutile*, n. sp.**

A black-bodied gray pollinose species with rufous legs similar to *rufipes*, from which it differs in several seemingly important characters listed below among others.

Male.—Parafrontal and parafacial pale yellowish gray pollinose, cheek groove more thinly so showing red ground color; parafacial with scattered black setae beneath the lowermost frontals; frontalia red, narrowed upwards and pinched out before triangle; vertex 0.13 of head width; antenna reddish yellow, third segment brownish, well narrowed from apex of second and but little longer than same; palpus yellow, slender to tip; haustellum bristlelike but hardly one-third longer than head height; cheek width in profile one-half eye length; thorax and scutellum black with moderately heavy gray pollen, notum marked with four dark vittae which appear best defined and reduce to three in number when viewed in a flat rear angle; anterior spiracle brown; wing grayish hyaline; calypter opaque white; epaulet black.

Female.—Vertex 0.30 of head width; two vertical and two proclinate orbital bristles; antenna wholly red, third segment subequal to length of second; haustellum-labellum bristlelike, one-half longer than head height; palpus longer than antenna with tip swollen; intermediate abdominal segments each with one pair of discals and a complete discal row on fourth; genitalia black telescopically retracted within anal orifice.

Length, 10-11 mm.

Holotype male, Martinez, Contra Co., Calif., September 14, 1946 (H. E. Cott). Paratype: 1 female, Catalina Mts. Ariz., Hk. Hy., October 11, 1955 (G. D. Butler).

The haustellum is shorter than usual in the male but approaches normal length in the female. This difference sounds more convincing than it appears on comparison in the presence of other pertinent characters which are in close agreement. More material may eventually show this provisional segregate to fall within the limits of *rufipes*.

***Mochlosoma russulum*, n. sp.**

Differs from *sabroskyi* as listed in the key; additional differentiating items are summarized below.

Male.—Parafrontal, posterior orbit and occiput above neck gray pollinose on dark background, parafacial and cheek with yellowish pollen on pale ground color; red frontalia reduced to width of anterior ocellus before triangle; parafacial sparsely black-haired on upper third; facial carina somewhat stronger, crest narrow and transversely angular at mid-face level; cheek one-half eye length, with a fringe of black hairs on lower edge; eye one-half as wide as long, not reaching to vibrissal level, facets almost uniform in size throughout. Thorax and scutellum red in ground color, notum, except prescutellar area and lateral margins, decidedly darker or blackish and dusted with thin gray pollen leaving surface moderating shining when viewed from above. Pulvilli pale yellow, claws red and nearly equal to combined length of last two tarsal segments. Wing with a slight but rather uniform tawny tinge becoming darker near base, small cross vein lightly infuscated; epaulet deep red, beset with black hairs. Abdomen translucent, red with a narrow black median vitta, lightly sprinkled with pale pollen and upper surface moderately shiny in most views; intermediate segments each with three or more pairs of median discals (usually irregular in size and spacing) and a marginal row on second segment nearly complete dorsally; hypopygium reddish, accessory process large, plate-like shining black; penis polished black, flattened and ribbon like to distal fourth thence tubular terminating in a somewhat narrowed depressed membranous tip; forceps wholly red, fused but not strongly sclerotized, tapering from base to a subacute shiny tip.

Female.—Similar to male except for the usual sexual differences; mesonotum largely reddish in ground color with rather dense opaque grayish pollen; abdomen without a well defined median vitta, intermediate segments each with one pair of median discals; genitalia as in *sabroskyi*.

Length, 12-14 mm.

Holotype male and allotype female, Mixquic, D. F., Mexico, August 18, 1949 (W. G. Downs). Paratypes: 1 pair, same data as type.

***Mochlosoma opipare*, n. sp.**

Usually a little less robust in build than *M. russulum;* also, more decidedly pollinose and grayer in general aspect. Most of the outstanding distinguishing items are contained in the accompanying key.

Male.—Parafrontal and parafacial gray to silvery pollinose on dark background, only the broad cheek groove and frontalia red; latter greatly narrowed before triangle; parafrontal sparsely beset with black hairs which extend almost to middle of broad parafacial; antenna red to arista thence blackish to subpointed tip, second segment over one-half length of third; facialia with two or three bristly hairs on lower extremity, flattened and depressed beneath parafacial level on upper half; vibrissae far above oral margin; haustellum slender and

bristlelike, approximating twice head height; eye twice longer than wide, with lower extremity well above vibrissal level, facets uniformly small or ordinary in size; cheek one-half eye length; palpus yellow, subcyclindrical, bearing a few long black hairs apically; occiput cinereous, somewhat bulged below and clothed with white pilose hairs. Thorax black, gray pollinose, scutellum red, this color extending forward on sides to include humeri and an indefinite prescutellar area, meso- and sternopleura also usually reddish in part; five dorsal vittae before suture and four less distinct ones behind. Legs moderately long and slender, red, tarsi black, femora and tibiae lightly pale pollinose; pulvilli infuscated, claws black, exceeding length of apical tarsal segment. Wing reaching well past tip of abdomen, uniformly pale tawny; epaulet infuscated, lightly sprinkled with lustrous white pollen; subepaulet yellow to brown; calypter as broad as long, translucent or yellowish white. Abdomen red, marked with an uninterrupted black median vitta and thinly dusted above with changeable white pollen; hairs long and erect on median line; two pairs of median discals on intermediate segments, a marginal row on last two and an incomplete marginal row on second segment; anal segment with two or three rows of irregularly spaced bristles behind middle above; hypopygium red, small and retracted; fifth sternite lobes black, sparsely fine-haired.

Female.—Similar to male except the usual sexual differences.

Length, 11-17 mm.

Holotype male and allotype female, Cherry Cr. Buttes, Arizona, September 19 and 21 (C. H. T. Townsend) in the U.S. National Museum. Paratypes: 2 males, same data as type; 1 pair, Sierra Madre, Chihuahua, Mexico, September 5 and 11 (C. H. T. Townsend); 1 male, "Guanajuato, Mex., (A. Duges)"; 3 males and 2 females, Chiricahua Mts., Arizona, September 29, 1947 (D. J. & J. N. Knull); 1 female, Sedona, Arizona, September 14, 1955 (G. D. Butler) and 1 female, Datil, New Mexico, September 18, 1939 (C. B. Philip).

***Mochlosoma laudatum*, n. sp.**

Abdomen red with a well defined black median vitta as in *opipare*, from which it differs in averaging considerably smaller in build; antennae wholly orange red; abdominal pollen yellowish to subgolden, etc.

Male.—Front greatly narrowed above and frontalia usually pinched out before triangle; vertex 0.13 of head width; parafacial and parafrontal sparsely black-haired, gray pollinose on dark background; antenna rather small, third segment subequal to length of second; haustellum slender and bristlelike, averaging a little less than twice head height; palpus yellow; barely widened distally; cheek profile width one-third eye length; thorax black lightly dusted with gray pollen, mesonotum feebly shiny, vittae poorly defined; scutellum usually reddish with base and median line infuscated; legs black, tibiae, apices of femora and trochanters reddish yellow; claws blackish, about equal length of last tarsal segment; wing gray hyaline tinged with yellow on costal margin and along longitudinal veins; costal spine vestigial; calypter opaque yellow sometimes with a whitish sheen; epaulet black, subepaulet red; fringe of anterior spiracle pale yellow; postnotal slope setose; hypopygium caudoventral, small and retracted in repose; forceps small and slender as usual; apical segment of penis subtubular, about one-third as long as the shining flattened penultimate segment; fifth sternite mostly black, lobes moderately exposed and rather thickly beset with coarse black hairs.

Female.—Front at vertex 0.33 of head width, diverging gradually forward to base of antenna; ocellar bristles strong and divergent; outer verticals well

developed; two pairs of proclinate orbitals; frontalia subequal parafrontal width; legs red, tarsi black, coxae also more or less infuscated; genitalia telescopically retracted within tip of abdomen, terminating in a fleshy blunt-tipped organ; claws and pulvilli shorter than last tarsal segment.

Length, 8-12mm.

Holotype male, Rio Frio, Mex., September 3, 1947 (F. A. Cowan & M. R. Wheeler); allotype female, "Xochimilco, D. F., W. G. Downs". Paratypes: 3 males, same data as holotype; 2 males, same data as allotype; 1 male, Neriaco, Mex., 10,500 ft., October 27, 1946 (W. G. Downs); 26 males and 6 females, "10 mi. E. San Juan del Rio, Quer., Mex., 6,500 ft. Univ. Kans. Mex. Expedition".

***Mochlosoma adustum*, n. sp.**

A moderately large species similar to *furtum* in general aspect, but the abdomen is more shining above and the sides are usually rufofuscous in ground color.

Male only.—Head pollen cinereous on dark background, cheek groove paler or reddish; frontalia red, much narrowed upwards but not completely pinched out before ocellar triangle; vertex 0.13 of head width; parafrontal clothed with black hairs which extend down on parafacial almost to cheek groove; antenna red, third segment infuscated on apical half or more; haustellum slender, long and bristlelike; palpus reddish yellow, almost equibroad from base to apex; cheek slightly under two-fifths eye length; thorax black dusted with gray pollen, scutellum red, this color normally extending forward on lateral margin of mesonotum and including humerus; notal vittae narrow and poorly defined; anterior spiracle orange yellow; legs shining black tibiae obscurely reddish; pulvilli and reddish black-tipped claws longer than last tarsal segment; wing with a light brownish tinge along veins becoming darker near base; calypter and epaulet black; abdomen practically pollenless but anal segment thinly pruinose on sides; hypopygium small and retracted, fused genital forceps slender to apex; accessory process shining black, strongly convex on lateral face, which is sparsely setiferously punctate; fifth sternite lobes well exposed, infuscated and clothed with black hairs.

Length, 11.5-14 mm.

Holotype: Mound Valley, Chih., Mex., VIII-23,09 (C. H. T. Townsend), at flws. of *Rudbeckia*. Paratypes: 4 males, same data as type.

***Mochlosoma anale* Giglio-Tos**

Mochlosoma anale Giglio-Tos, 1893, Boll. Mus. Zool. Univ. Torino, 8, No. 147; Ditt. del Mess., 3: 55.

Prosena analis (Giglio-Tos) Aldrich, 1905, Cat. N. A. Diptera, p. 496.

Trochliodexia anale (Giglio-Tos) Townsend, 1915, Proc. Biol. Soc. Wash., 28, 22; 1937, Manual of Myiology, Pt. 7, 382-383.

A rather large black-bodied species with the general habitus of *mexicanum*, from which it is at once distinguished by the black calypters and in having the pale abdominal pollen restricted to the anal segment. Additional differences are listed below:

Male and female.—Head subsilvery pollinose; parafrontal sparsely clothed with black hairs which extend downward almost to middle of parafacial; male frontalia pinched out before triangle and latter but slightly narrower than vertex; antenna rufous, third segment often infuscated apically; cheek thinly pollinose on red background; epistoma and clypeus blackish. Thorax and scutellum black lightly dusted with gray pollen; pronotal vittae narrow but moderately well defined before suture, obsolete behind latter; legs black, tibiae yellowish with

base and apex of each usually darker or blackish; wing with a rather uniform light brownish tinge becoming slightly darker basally; epaulet and calypter black. Abdomen wholly black, first three segments practically pollenless and feebly shining above, anal segment with conspicuous pale pollen and contrasting sharply with preceding ones in most views; hypopygium black, rather small; forceps slender, accessory process very large and platelike; penis depressed, jointed near basal and apical third, distal segment tapering to a narrow membranous tip; fifth sternite black, exposed lobes moderately black-haired.

Length, 11-13.5 mm.

Material examined includes 28 specimens (both sexes) all from Mexico: Rio Frio, September 9, 1947 (F. A. Cowan & M. R. Wheeler); Mexico City, 1,000 ft. July (W. G. Downs); West Slope Cortes Pass, 9,000 ft. August 13, 1954 (R. R. Dreisbach, University Kans. Mex. Expedition).

***Mochlosoma furtum*, n. sp.**

Habitus quite similar to *anale*, but at once distinguished by the total absence of pale pollen on the abdomen. Other differences are listed below.

Male only.—Front broader before triangle than in most allied forms, vertex 0.19 of head width; frontalia wider than parafrontal on entire length; parafrontal parafacial and cheek silvery pollinose on blackish background; antenna rufous, third segment more or less infuscated beyond middle parafacial rather sparsely black-haired on upper half or less; cheek one-third eye length; haustellum long and bristle-like; palpus reddish yellow, rather short and stoutish, enlarged tip beset with long black hairs; thorax and scutellum thinly gray pollinose on black ground color; notal vittae narrow and poorly defined; anterior spiracle brownish black; wing subhyaline slightly yellowish costobasally; calypters deep brown to blackish; abdomen opaque black, strongly bristled; genitalia black, caudoventral and mostly retracted in repose.

Length, 10-11 mm.

Holotype: Oaxaca, Oaxaca, Mex., September 19, 1923 (E. G. Smith) in the U.S. National Museum. Paratypes: 4 males, same data as type.

***Mochlosoma mexicanum* (Macquart)**

Prosena mexicana Macquart, 1851, Dipt. Exot., Suppl. 4, 231. Brauer & Bergenstamm, 1890, Zweifl. d. Kaiserl. Mus., 5, 406.

Some confusion has prevailed regarding the identity of this species. *Prosena tessellans* van der Wulp was originally described with an element of doubt regarding its distinctness from *P. mexicana* Macquart, and there is nothing in the description to indicate decisive differences here. However, for some inexplicable reason Aldrich subsequently assigned *mexicana* to *Thelaira* (Catalogue N. A. Diptera, 1905, 507). The latter genus (type *Musca nigripes* F.) differs widely in many characters, among which perhaps the most obvious is the short stout haustellum, which bears large or fleshy labella. The type specimens of *mexicanum* and *tessellans* were not available for the purpose of this review.

As here considered *mexicanum* may be briefly characterized as follows:

Male and female.—Head pollen pale cinereous, parafrontal and parafacial at times with a slight tawny tinge; vertex 0.14 (male) to 0.29 (female) of head width; antenna red, third segment brownish apically; male frontalia narrowed upward but not pinched out before triangle and in female wider than parafrontal except on anterior extremity; parafrontal with pale hairs below middle extending downward about to middle of parafacial; slender haustellum reaching beyond mid venter; male without orbitals or differentiated outer verticals; occiput clothed with pale yellowish white pile. Thorax and scutellum wholly black, dusted with

moderately heavy opaque grayish pollen, marked with four or five narrow dark vittae, which are less distinct behind suture; anterior spiracle fringed with reddish hairs; legs black tibiae largely reddish in ground color female claws and pulvilli shorter than apical tarsal segment; wing with a distinct yellow tinge costobasally becoming grayer distally; epaulet black; calypter pale yellowish white. Abdomen black, with grayish pollen above extending from first segment to about middle of third, thence the surface is moderately shiny to apex of anal segment; male genital forceps slender and acute-tipped; fifth sternite lobes black and rather broadly exposed.

Length, 11-14 mm.

Material examined: 36 specimens (including both sexes) from Mexico City, D. F., Mex., 6,500 to 10,000 ft. August to October, collected by W. G. Downs, members of the Univ. Kans. Mex. Expedition, and R. R. Dreisbach.

***Mochlosoma sabroskyi*, n. sp.**

Male.—Front at vertex 0.10 of head width, narrowed forward and sublinear before triangle thence widening to over one-third head width at antennal base; head pollen satiny yellow to subgolden on pale ground color, parafrontal slightly darker, beset with mostly yellow hairs which extend downward to about middle of parafacial, which equals clypeal width; facialia flattened and nearly one-half clypeal width, with one to three bristly hairs next to vibrissae, which are far above oral margin; antenna yellow, first segment short, second widened apically, over half as long as third; cheek one-third eye height, with pale and black hairs on lower margin; eye about three-fourths as wide as long, reaching almost to vibrissal level, facets considerably enlarged on upper half or more; haustellum long and bristlelike reaching well past venter base; palpus yellow, longer than antenna; occiput considerably swollen below middle, pale pollinose on yellow background and clothed with whitish to yellow pile.

Thorax mostly pale in ground color, with heavy lusterless yellow pollen approaching old gold on mesonotum, which is vaguely marked with four narrow dark vittae and clothed with a vestiture of fine black hairs nearly half as long as interspaced macrochaetae; scutellum wholly yellow with somewhat thinner pollen; anterior spiracle enlarged about as long as antenna, fringed with pallid plumose scalelike hairs. Legs long and rather slender, red with tarsi black; claws and pulvilli infuscated, equal to or exceeding length of last tarsal segment. Wing hyaline with a light yellowish tinge, which is more pronounced along veins, near base and along costa to tip of first vein; costal spine vestigial; hind cross vein three-fourths its length from cubitulus, which is about one-fifth wing width from hind margin; epaulet and subepaulet yellow; calypter large opaque tawny to light brownish yellow.

Abdomen translucent reddish yellow; lightly dusted with pale changeable pollen; two median and three lateral marginal bristles on second, a marginal row on last two segments, usually one pair of discals on intermediate segments and fourth with two or three irregular rows of discals; hypopygium rather small, retracted; fifth sternite with a deep median V-shaped excision, lobes sparsely black-haired.

Female.—Vertex 0.35 of head width; outer vertical over half as long as inner; two large proclinate orbitals; red frontalia wider than parafrontal; cheek three-fifths eye height; claws and pulvilli shorter than apical tarsal segment; genitalia telescopically retracted within anal orifice, terminating in a fleshy blunt-tipped segment which is clothed with black pile.

Length, 13-15.5 mm.

Holotype male and allotype female, Michoacan, Mexico, August 9, 1954 (R. E. Ryckman, D. Spencer, C. P. Christianson) in the U.S. National Museum. Paratypes all from Mexico as follows: 1 male, Mexico City, (Juan Muller); 2 females, Quiroga, Micho., September 14, 1947 (W. G. Downs); 1 female, Huipulco, D. F., August, 1923 (E. G. Smyth); 2 males and 1 female, Cuernavaca, Mor., August 15, 1954, 7,100 ft., 2 males, Veracruz, June 29, 1953, 6,600 ft., 2 males El Salto, Dur., July 23, 1953, 7,900 ft., 1 female, Mexico City, D. F., August 16, 1954, 8,900 ft., and 1 female, Hidalgo, Micho., June 16, 1953, 6,400 ft., all taken by members of the University Kans. Mex. Expedition; 1 male, Mexico City, D. F., July 29, 1928 (G. Lassmann), 1 female, Zamora, Mich., August 27, 1947 (F. A. Cowan & M. R. Wheeler) and 1 male, Cuernavaca, August 15, 1934, without collector's label.

The species, named for Curtis W. Sabrosky, is allied to *Mochlosoma lacertosum* (van der Wulp) but may be distinguished by the narrower male front and color differences listed above.

***Mochlosoma lacertosum* (van der Wulp)**

Prosena lacertosa van der Wulp, 1891, Biol. Cent. Am. Dipt., 2: 214-215.

Very similar to the preceding species, differing chiefly as follows:

Male.–Head pollen paler yellowish gray, male front obviously wider measuring 0.12 of head width at apex of triangle; frontalia narrowed but not completely pinched out at upper extremity; parafacial wider than clypeus; eye narrower, about half as wide as long, facets not uncommonly enlarged above middle; mesonotal pollen opaque gray, at most with a slight yellowish tinge apparent when viewed at a flat rear angle.

Female vertex 0.30 of head width (one specimen); frontalia narrower than parafrontal width before mid front; cheek four-sevenths eye height; hind cross vein barely half its length from cubitulus.

Length, 12-14.5 mm.

Material examined: 4 males and 1 female all from Mexico (type locality, Durango, 8,100 ft.). The U.S. National Museum contains a long series from Chihuahua, Mexico, taken at flowers of *Rudbeckia* by the late Dr. C. H. T. Townsend.

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B & Z Library

Note on Population Densities of Spiders (Araneae) in Nova Scotia Apple Orchards[1]

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Chant (1956) has shown that spiders are common predators in apple orchards in southeast England. Dondale (1956) listed the species of spiders found in Nova Scotia orchards. This is a note on population densities in the latter orchards from 1953 to 1956.

The sampling device used in this study was a cloth-covered, yard-square tray (Lord, 1956), supplemented in a minor way by a collecting umbrella. Each tray or umbrella collection represented the spiders jarred from the lower branches of a single tree, or from the lower branches of half of each of two trees.

There were two peaks in numbers of active spiders annually, a small one in the spring and a much larger one in late summer (Table I). Observations by Weese (1924), Elliott (1930), and Engel (Vité, 1953) suggest that this may be the normal trend in arboreal spiders in the North Temperate zone. The spring peak appeared during June, and was attributed mainly to an influx of spiders from overwintering niches on tree trunks and on the ground. A small amount of this increase was attributed to the hatching of eggs of a few minor species that overwinter in this stage, e.g., *Zygiella atrica* (C. L. Koch). The late-summer peak appeared very late in August or early in September; it resulted from hatching of eggs of the majority of species.

TABLE I
Average numbers of spiders taken on six or more trays at twice-monthly intervals in about 40 orchards, Kentville, Nova Scotia, 1953–56

Year	May		June		July		August		September		October	
	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
1953	3	8	16	11	9	12	20	26	24	–	–	–
1954	–	9	10	6	7	9	17	18	23	–	–	–
1955	–	8	9	9	7	28	19	46	48	22	21	14
1956	–	9	17	21	16	15	36	43	59	54	49	16
Average	3	9	13	12	10	16	23	33	39	38	35	15

Periods of decline in numbers following the peaks were observed in late June or early July and in late September and October. The decline in early July was at first thought to be associated with adult males, which were presumed to die soon after appearing and mating in May and June (Kaston, 1948). When adult males, adult females, and immature individuals were separated in samples taken in late June and early July, however, the decline was observed in all three groups. It thus seems to be the result of some general environmental influence, e.g., interaction with other predators. The autumnal decline was associated with the movement of spiders to overwintering niches.

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TABLE II

Average numbers of five principal species of spiders taken per tray on 13 or more trays at twice-monthly intervals in two orchards, Kentville, Nova Scotia, 1955–56 (percentages of total numbers of spiders in parentheses)

Species	June		July		August		September		October	
	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
Paraphidippus marginatus	1(9)	2(13)	1(9)	4(24)	5(16)	6(16)	5(12)	5(10)	1(3)	1(7)
Metaphidippus protervus	1(9)	2(13)	1(9)	2(12)	5(16)	7(19)	6(15)	5(10)	2(7)	1(7)
Philodromus cespiticolis	1(9)	2(13)	2(18)	3(18)	7(23)	4(11)	6(15)	6(12)	6(19)	1(7)
Philodromus rufus	1(9)	2(13)	2(18)	1(6)	3(10)	5(14)	6(15)	8(16)	2(7)	2(14)
Araniella displicata	1(9)	1(6)	1(9)	1(6)	3(10)	7(19)	9(22)	13(26)	10(32)	7(47)
Total	5(45)	9(58)	7(63)	11(66)	23(75)	29(79)	32(79)	37(74)	21(68)	12(82)

Spiders formed a large percentage of the predators active in orchards in May and early June (± 45 per cent), and from August to October (± 55 per cent). During late June and July, active stages of other predatory groups, e.g., Miridae, were present in relatively large numbers, reducing the percentage of spiders to ± 29 per cent.

Orchard spiders can, except two minor families (Clubionidae and Anyphaenidae), be grouped according to method of capturing prey, as follows: Salticidae, which "hunt" by sight; Thomisidae, which detect their prey by sense of touch; and several families of web-builders, whose activities are primarily associated with aerial webs. Although the three groups were represented by approximately the same numbers of active individuals from May to October in 1955 and 1956, they comprised respectively 14, 23, and 62 per cent of the species present.

Five species formed a large percentage of the spider population in the years 1955 and 1956 (Table II).These were *Paraphidippus marginatus* (Walckenaer), *Metaphidippus protervus* (Walckenaer), *Philodromus cespiticolis* Walckenaer, *Philodromus rufus* Walckenaer, and *Araniella displicata* (Hentz). All five were also collected commonly from tall ground-cover plants and wooded borders of orchards. Orchards thus appeared to offer suitable conditions in which these species could feed and reproduce in relatively large numbers.

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Biological and Descriptive Notes on Noctuid Larvae[1]

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Introduction

These observations, dealing with noctuid larvae, were made while the writer was associated with the Canadian Forest Insect and Disease Survey. Twenty-four species have been examined: 9 in the Hadeninae, 10 in the Cucullinae, 3 in the Amphipyrinae, and 2 in the Catocalinae. The arrangement of the subfamilies follows that of McDunnough (1938). This material is being published because many of these species have not been included in Crumb (1956) and new data are presented on the species considered by him. The descriptions were made from living and preserved larvae. Notes on biologies, unless otherwise indicated, refer to those made by the writer in Manitoba and Alberta during the years 1944-1954. The hosts are those on which larvae have been reared to adults by the Forest Insect and Disease Survey, except in a few cases where the host is cited from the literature. "Free-living larvae", are those that feed openly. When the number of instars is not known the larvae are described as antepenultimate, penultimate, and ultimate. In measurements, H.W. refers to head width, B.L., to total larval length, and B.W., to greatest larval width.

Hadeninae

Polia lutra Guenée (Fig. 10.

Range: Nova Scotia to North Carolina, and west to British Columbia (Forbes, 1954).

Hosts: *Shepherdia canadensis* (L.) Nutt., *Betula* spp., *Alnus* spp., *Cornus stolonifera* Michx., *Ribes* spp. and *Prunus* spp.

Life History: Larvae, free-living, in August and September; hibernate as pupae; adults from March until July in British Columbia (Jones, 1951) and from June 10 until August 7 in Nova Scotia (Ferguson, 1955).

Description: *Antepenultimate*: Larva green. *Penultimate*: Head pale yellow-green with brown reticulate markings. Thorax and abdomen yellow-green; fine yellow lines in middorsal, subdorsal, and spiracular regions. *Ultimate*: Head pale brown, with brown reticulate markings. Thorax and abdomen patterned, ground colour yellow; middorsal line geminate, grey or brown, darker at intersegmental regions; brown herring-bone pattern on dorsum (cf. Crumb, 1956), spiracular line fine, brown; subspiracular line yellow; venter pruinose grey or pale brown with brown mottling. Number of larvae examined: 10.

Measurements: Antepenultimate: H.W., 1.52 mm. Penultimate: H.W., 2.09-2.47 mm.; B.L., 15-30 mm.; B.W., 2.5-3.0 mm. Ultimate: H.W., 3.35-4.18 mm.; B.L., 25-38 mm.; B.W., 5.0-7.0 mm.

Polia cristifera Walker (Fig. 12).

Range: Hudsonian zone in Canada (Forbes, 1948); probably more abundant in British Columbia and Alberta than farther east.

Hosts: *Shepherdia canadensis* (L.) Nutt., *Cornus stolonifera* Michx., *Betula* spp., *Ribes* spp., and *Larix laricina* (Du Roi) K. Koch.

Life History: Larvae from late July until early October, free-living; hibernate as pupae; adults in May, June, and July.

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Description: *Penultimate*: Head pale whitish-green, without markings, or yellow with brown reticulations. Thorax and abdomen, yellow or yellow-green, with brown herring-bone pattern on dorsum; middorsal line geminate, brown or green, supraspiracular line brown, spiracular line white; venter yellow or yellow-green with mottlings of white or brown. *Ultimate*: Much as in penultimate but brown herring-bone pattern more conspicuous (cf. Crumb, 1956). Number of larvae examined: 5.

Measurements: Antepenultimate: H.W., 1.14 mm. Penultimate: H.W., 2.28-2.47 mm.; B.L., 15-28 mm.; B.W., 2.2-4.0 mm. Ultimate: H.W., 3.00-3.42 mm.; B.L., 27-38 mm.; B.W., 4.0-5.3 mm.

POLIA INGRAVIS Smith (Figs. 1 and 11).

Range: Transcontinental in Canada (Ferguson, 1955, and Jones, 1951).

Hosts: *Shepherdia canadensis* (L.) Nutt., *Salix* spp., *Ribes* spp., *Populus* spp., and *Larix laricina* (Du Roi) K. Koch.

Life History: Larvae from July 17 to September 29, free-living; hibernate as pupae; adults in May, June, and July.

Description: *Penultimate*: Head pale brown with reticulate markings. Thorax and abdomen pale brown; middorsal line geminate brown; dorsum with herring-bone brown markings. *Ultimate*: Head as penultimate in pattern. Thorax and abdomen may be much as penultimate or ground colour may be pale grey, with dorsum heavily mottled with dark grey; dark grey obliques between dorsal setae, and grey spiracular line. No. of larvae examined: 4.

Measurements: Penultimate: H.W., 2.30 mm.; B.L., 24 mm.; B.W., 3.0 mm. Ultimate: H.W., about 3.00 mm.; B.L., 27-33 mm.; B.W., 4.0-5.0 mm.

POLIA SEGREGATA Smith.

Range: Ontario to British Columbia.

Hosts: *Shepherdia canadensis* (L.) Nutt. and *Eleagnus* sp.

Life History: Larvae in August and September, free-living; hibernate as pupae; adults in April and May (Bowman, 1951).

Description: *Penultimate*: Head honey-yellow, with a black dot at each setal base. Thorax and abdomen with grey dorsum and pale grey venter; middorsal and supraspiracular lines fine, pale; spiracular stripe white. *Ultimate*: Head pale brown with a brown patch on each parietal lobe. Thorax and abdomen mottled grey to supraspiracular area; venter pale grey; fine broken lines in middorsal and supraspiracular regions. No. of larvae examined: 1.

Measurements: Penultimate: H.W., 1.90 mm.; B.L., 17 mm. and B.W., 2.0 mm. Ultimate: H.W., 3.50 mm.; B.L., 24 mm.; B.W., 3.0 mm.

Remarks: Larva collected at Jasper, Alberta, on *Shepherdia*, on July 20, 1953 (Forest Insect Survey, Record No. 1953 Alberta 844B); pupated August 18; emerged, after hibernation, as a male.

XYLOMYGES DOLOSA Grote (Figs. 2 and 13).

Range: Nova Scotia (Ferguson, 1955) to British Columbia (Jones, 1951) in Canada and New York, New Hampshire, and Colorado in United States (Forbes, 1954).

Host: *Populus* spp.

Life History: Larvae from middle of June until end of August, feeding in shelter of leaves tied together; hibernate as pupae; adults in April and May.

Description: *Penultimate*: Head brown with dark brown reticulate markings. Thorax and abdomen vary from black to purplish-grey; fine white middorsal, supraspiracular, and subspiracular lines; venter purplish-grey; prothoracic

plate white with large brown patch on either side; thoracic legs pale, with black tarsi; prolegs, pale grey. *Ultimate*: Head patterned as in penultimate stage. Thorax and abdomen pale grey or black, with fine white lines in middorsal, supraspiracular, and spiracular areas; prothoracic plate grey. No. of larvae examined: 5.

Measurements: Antepenultimate: H.W., 1.90 mm. Penultimate: H.W., 2.28-2.56 mm. Ultimate: H.W., 3.04-3.42 mm.; B.L., 22-27 mm.; B.W., 3.0-3.8 mm.

XYLOMYGES sp. prob. VARIABILIS Smith.

Range: Southwestern Alberta.

Host: *Pinus flexilis* James.

Life History: Larvae, free-living, in June and early July; hibernate as pupae; adults probably about April.

Description: *Antepenultimate*: Head honey-yellow with a black dot at each setal base; thorax and abdomen green, with fine cream-coloured lines in middorsal, and supraspiracular regions; spiracular stripe broad, yellow-green. Setal bases black. *Penultimate*: Colour pattern much the same as in antepenultimate stage. *Ultimate*: Head honey-yellow with black dots at setal bases. Thorax and abdomen yellow-green; middorsal and supraspiracular lines white or yellow, flanked on each side by a fine black line; spiracular stripe yellow-green, flanked by fine yellow lines; prothoracic plate green. No. of larvae examined: 4.

Measurements: Penultimate: H.W., about 2.00 mm.; B.L., about 25 mm.; B.W., about 2.3 mm. Penultimate: H.W., 1.85-1.90 mm.; B.L., about 20 mm.; B.W., about 3.0 mm. Ultimate: H.W., 2.00 to 2.28 mm.; B.L., about 25 mm.; B.W., 3.0-4.0 mm.

ORTHOSIA HIBISCI Guenée.

Range: Nova Scotia (Ferguson, 1955) to British Columbia (Jones, 1951) in Canada, and north of Maryland, Pennsylvania, Ohio, Illinois, Missouri, Kansas, New Mexico, Utah, and California in the United States (Crumb, 1956).

Hosts: Species of *Salix*, *Betula*, *Alnus*, *Populus*, *Larix*, and *Picea*.

Life History: Larvae from May in Eastern Canada until early August in Western Canada, free-living; hibernate as pupae; adults in April and May.

Description: *Penultimate*: Head pale green with faint grey reticulations. Thorax and abdomen green; middorsal, supraspiracular, and subspiracular lines, white. *Ultimate*: Head pale green or pale brown, usually with faint reticulations. Colour of thorax and abdomen as in penultimate stage (cf. Crumb, 1956). No. of larvae examined: 7.

Measurements: Penultimate: H.W., about 2.00 mm.; B.L., about 25 mm.; B.W., about 4.0 mm. Ultimate: H.W., 3.04-3.42 mm.; B.L., 27-36 mm.; B.W., 4.0-5.6 mm.

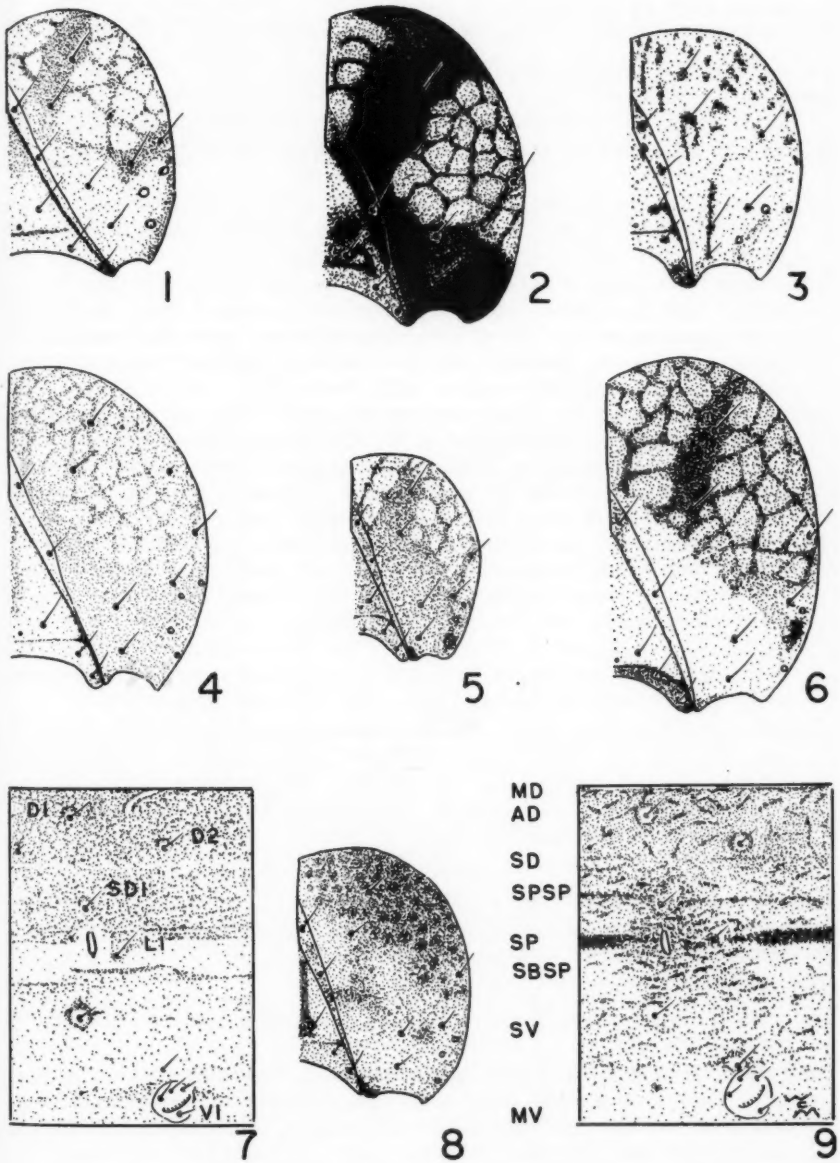
ORTHOSIA REVICTA Morrison (Fig. 16).

Range: Nova Scotia to British Columbia, in Canada; Maine, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Washington, Oregon, Idaho, Utah, and Colorado, in United States (Crumb, 1956).

Hosts: *Populus tremuloides* Michx. and species of *Betula*, *Salix*, *Alnus*, *Larix*, and *Picea*; Crumb (1956): *Spiraea douglasii* Hook. and *Malus pumila* L.

Life History: Larvae, in June, July, and August, free living; hibernate as pupae; adults in April and May.

Description: *Ultimate*: Head pale brown with brown reticulations on parietal lobes, and brown arcs on each side of epicranial suture. Thorax and abdo-



Figs. 1-6 and 8. Colour and setal patterns of frontal aspect (left half) of head. Figs. 7 and 9. Colour and setal patterns of third abdominal segments. 1. *Polia ingravis* Sm. 2. *Xylomyges dolosa* Grt. 3. *Pleroma cinerea* Sm. 4. *Xylena thoracica* Put.-Cram. 5. *Bombycia algens*, Grt. 6. *Andropolia contacta* Wlk. 7. *Homoglaea carbonaria* Harv. 8. *Enargia infumata* Grt. 9. *Andropolia contacta* Wlk.

men grey-green, with fine, white middorsal and subdorsal lines; subspiracular stripe, white or pale brown (cf. Crumb, 1956). No. of larvae examined: 5.

Measurements: Ultimate: H.W., 2.85 mm.; B.L., 25 mm.; B.W., 3.5 mm.

CROCIGRAPHA NORMANI Grote.

Range: In Canada, from Nova Scotia (Ferguson, 1955) west to Alberta (Bowman, 1951), and in United States, New Jersey west to Pennsylvania (Crumb, 1956).

Hosts: *Tilia americana* L., *Malus pumila* L., and species of *Prunus*, *Corylus*, and *Ribes*.

Life History: Eggs hatch about June 11 in vicinity of Winnipeg, Manitoba; larvae, free-living, feed in June and July; hibernate as pupae; adults in May and June.

Description: *First stage*: Head light brown; thorax and abdomen shining lemon-yellow, with black setal bases. Setae long, dark. *Second stage*: Head light brown, sometimes with one or two pairs of brown spots on parietal lobes; thorax and abdomen pale with fine, pale middorsal line; grey addorsal stripe, and black supraspiracular stripe. Setal bases black. *Third stage*: Head honey-yellow with two black spots on each parietal lobe, one spot above the ocellar area and the other mesad of it. Thorax and abdomen white, with grey-green addorsal region; white subdorsal line bordered above with grey line; supraspiracular stripe grey; subventral stripe white; venter light grey. *Fourth stage*: Head as in third instar. Thorax and abdomen much as in third instar; white patch laterad of dorsal setae on abdominal segments. *Fifth stage*: Head honey-yellow; the spots on head are no longer round. Thorax and abdomen marked as before (cf. Forbes, 1954). *Sixth stage*: Head honey-yellow with brown reticulations over parietal lobes; the reticulations form dark arcs on either side of the epicranial stem. Thorax and abdomen pale brown; dorsum brown, with suggestion of pale middorsal line; venter pale brown (cf. Crumb, 1956). No. of larvae examined: 4.

Measurements: First stage: H.W., 0.41-0.43 mm. Second stage: H.W., 0.66-0.69 mm.; B.L., 6.0 mm. Third stage: H.W., 0.97-1.08 mm.; B.L., 9.0 mm.; B.W., 1.0 mm. Fourth stage: H.W., 1.56-1.64 mm.; B.L., 13.0 mm.; B.W., 2.0 mm. Fifth stage: H.W., 2.27-2.40 mm. Sixth stage: H.W., 3.4 mm. (Crumb, 1956); B.L., 35-40 mm.; B.W., about 5.5 mm.

Cucullinae

PLEROMA CINEREA Smith. (Figs. 3 and 14).

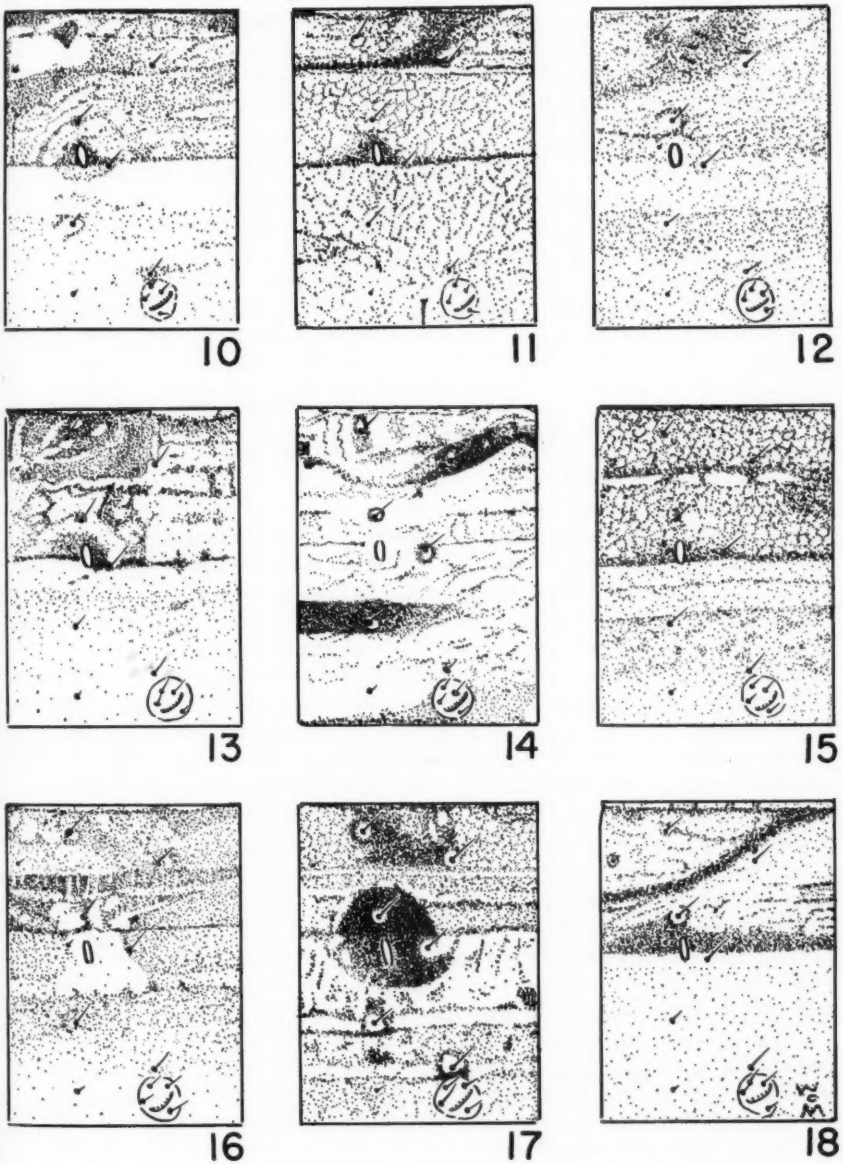
Range: Southwestern Alberta, southern British Columbia (Jones, 1951) and Washington(Crumb, 1956).

Host: *Symphoricarpos* sp.

Life History: Larvae, free-living, in June; in pupal period in July; adults probably overwinter.

Description: *Ultimate*: Head pale brown with dark linear markings on parietal lobes; dark brown along sides of clypeus. Thorax and abdomen brown; dorsum darker than ground colour, with irregular lines; sinuate dark brown line through seta D-2; subdorsal region pale; spiracular area with many fine brown lines; subventral line dark brown, conspicuous on metathorax and abdominal segments 1 to 3 and 7 to 9; brown midventral line. (This description is similar to that of Sp. 15 of Crumb (1956)). No. of larvae examined: 1.

Measurements: Ultimate: H.W., 3.04 mm.; B.L., about 30 mm.; B.W., about 4.0 mm.



Figs. 10-18. Colour and setal patterns of third abdominal segments. 10. *Polia lutra* Gn. 11. *Polia ingravis* Sm. 12. *Polia cristifera* Wlk. 13. *Xylomyges dolosa* Grt. 14. *Pleroma cinerea* Sm. 15. *Bombycia algens* Grt. 16. *Orthosia revicta* Morr. 17. *Xylotype acadia* G. & R. 18. *Xylena thoracica* Put.-Cram.

ONCOCNEMIS PIFFARDI Walker.

Range: According to Forbes (1954) this species occurs from Nova Scotia to Alberta in Canada, and in Maine, New Hampshire, and New York in the United States.

Host: *Spiraea* sp.

Life History: Larvae, free-living, in June and early July; several weeks in pupal period; adults in late summer and fall.

Description: *Ultimate*: Head brown, with white and brown stripes on parietal lobes along frons. Thorax and abdomen brown; middorsal line light brown; spiracular region yellow-brown; subspiracular region yellow; venter pale brown with grey midventral line. Prothoracic shield dark brown. Setal bases white. No. of larvae examined: 2.

Measurements: Ultimate: B.L., 25 mm.; B.W., 2.5 mm.

Remarks: The larvae were collected June 13, 1946, near White Lake in the Whiteshell Forest Reserve, Manitoba. After pupating on July 8, the specimens emerged on August 5 and 7, as males. For descriptions of other larvae in this genus, see Crumb (1956) and McDunnough (1933).

BOMBYCIA ALGENS Grote (Figs. 5 and 15).

Range: Nova Scotia (Ferguson, 1955) to Alberta in Canada, and in Maine and New York in United States.

Hosts: *Salix* spp., *Populus tremuloides* Michx.

Life History: Larvae in June and July; free-living in later stages, possibly live in shelters in early stages; pupae in late summer; adults in August and September.

Description: *Ultimate*: Head pale brown with brown reticulations. Thorax and abdomen dark grey, brown or dark brown, with fine white middorsal and subdorsal lines; venter pale brown. No. of larvae examined: 4.

Measurements: Ultimate: H.W., 2.28-2.66 mm.; B.L., 22-30 mm.; B.W., 3.7-4.0 mm.

Remarks: The larvae of this species have been confused with those of *Orthosia revicta* and *Andropolia*; they can be distinguished from *Orthosia revicta* by the smaller head width, 2.28 to 2.66 mm. compared with 2.85 mm. or more in *O. revicta*, and the absence of the pale subspiracular stripe found in *O. revicta* (Fig. 16). *Andropolia contacta* also has a much larger head width, 3.80 to 4.18 mm., than *Bombycia* and a dark grey or black sinuate supraspiracular line (Fig. 9).

GRAPTOLITHA FAGINA Morrison.

Range: Nova Scotia and Quebec, to Pennsylvania and New Jersey, west to British Columbia and Washington (Forbes, 1954).

Host: *Betula* spp.

Life History: Larvae in June and July, free-living; from four to six weeks in pupal period; adults from October to April.

Description: *Ultimate*: Head white with grey-green reticulations. Thorax and abdomen yellow-green, covered on dorsum with white dots; middorsal, supraspiracular, and subspiracular lines fine, dotted, white; venter pruinose green. No. of larvae examined: 4.

Measurements: Ultimate: H.W., 3.13-3.40 mm.; B.L., about 40 mm.; B.W., about 3.5 mm.

GRAPTOLITHA THAXTERI Grote.

Range: Nova Scotia to British Columbia.

Host: *Larix laricina* (Du Roi) K. Koch.

Life History: Larvae in June and July, free-living; pupal period about four weeks; adults September and October to April and May.

Description: *Ultimate*: Head russet-green; Thorax and abdomen blue-green with many white markings on dorsum and sides; middorsal, supraspiracular and subspiracular lines white, fine. No. of larvae examined: 2.

Measurements: Ultimate: H.W., about 2.28 mm.; B.L., about 30 mm.; B.W., about 4.0 mm.

XYLOTYPE ACADIA Grote and Robinson (Fig. 17).

Range: Nova Scotia (Ferguson, 1955) to British Columbia (Jones, 1951).

Host: Species of *Picea* and *Alnus*; Forbes (1954): *Prunus virginiana* L.

Life History: Larvae, free-living, in June and the first part of July; in pupal stage in mid-summer; adults from August to October.

Description: *Ultimate*: Head pale brown with brown reticulate marking. Thorax and abdomen grey; dark grey dorsal markings; dark grey or black patch around spiracles; subspiracular stripe grey, with dark grey patches below spiracles; venter grey. Setal bases white (cf. Forbes, 1954, and Crumb, 1956). No. of larvae examined: 6.

Measurements: Ultimate: H.W., 2.85-3.04 mm.; B.L., 26-34 mm.; B.W., about 4.0 mm.

MNIOTYPE VERSUTA Smith.

Range: Alaska, British Columbia, Alberta, Washington, Montana, Idaho, Colorado, and New Mexico (Crumb, 1956).

Hosts: *Alnus, Cornus, Larix laricina* (Du Roi) K. Koch.

Life History: Larvae, free-living, hibernate; pupate in spring; adults in July.

Description: *Ultimate*: Head green with pale brown reticulation. Thorax and abdomen brown or green (cf. Crumb, 1956).

Measurements: Ultimate: H.W., 3.1 to 3.2 mm.; B.L., about 35 mm.; B.W., about 6 mm. No. of larvae examined: 2.

Remarks: The larva may resemble those of the species, *Polia cristifera*, in appearance but they differ in life history: *M. versuta* hibernates in the larval stage and *P. cristifera* in the pupal stage.

XYLENA THORACICA Putnam-Cramer (Figs. 4 and 18).

Range: Nova Scotia (Ferguson, 1955) to British Columbia (Jones, 1951) and in Alaska, Colorado, Utah, Arizona, Maine, New Hampshire, and New York (Forbes, 1954).

Hosts: Adults have been reared from larvae on: *Alnus, Salix, Cornus, Rosa, Betula, Ribes, Picea, Populus tremuloides* Michx.

Life History: Larvae, free-living, in June, July and August; pupation in late summer; adults in fall and spring.

Description: *Penultimate*: Head pale russet-green with no markings. Thorax and abdomen green with white markings; middorsal and lateral lines fine, broken, white; subspiracular line yellowish-white. *Ultimate*: Head pale brown with brown reticulations on parietal lobes; clypeus pale brown with brown line from apex to base; frons pale brown. Thorax and abdomen pale brown with geminate-grey middorsal line and grey herring-bone markings on dorsum of abdominal segments; supraspiracular line, pale geminate-brown; yellow line in subspiracular region (usually bears some spiracles); venter pale brown or pale green (cf. Sanders and Dustan, 1919). No. of larvae examined: 6.

Measurements: Antepenultimate: H.W., 1.90 mm.; Penultimate: H.W., 2.66-3.04

mm.; B.L., about 24 mm.; B.W., 3.0 mm. Ultimate: H.W., 4.00-4.50 mm.; B.L., 30-33 mm.; B.W., about 4.0 mm.

Remarks: Forbes (1954) notes that this species may be only a race of *X. cineritia* Grote. The adults appear to be much the same as those of *X. cineritia* and the food-plants and distributions are similar.

HOMOGLAEA CARBONARIA Harvey (Fig. 7).

Range: Alberta, British Columbia, and Washington.

Hosts: Commonly on species of *Populus*, occasionally *Salix*.

Life History: Larvae free-living, or in slight shelter of tied leaves, from early June until the middle of August; pupation in late July and early August; adults hibernate.

Description: *Antepenultimate*: Head honey-yellow. Thorax and abdomen pale green with fine dark middorsal line, fine white supraspiracular and white spiracular lines. *Penultimate*: Head pale brown with brown reticulations, these markings heaviest on face. Thorax and abdomen grey-brown; middorsal line scarcely visible; supraspiracular line fine, pale, bordered with dark colour; spiracular line rust colour; venter grey. Prothoracic plate velvety brown with a conspicuous white lateral line. Anal plate grey with pale lateral line. *Ultimate*: Head, thorax, and abdomen have much the same pattern as in penultimate stage. No. of larvae examined: 6.

Measurements: Early: H.W., 0.95 mm.; Antepenultimate: H.W., about 1.50 mm.; B.L., about 15 mm.; B.W., about 2.0 mm. Penultimate: H.W., 2.50 mm.; B.L., about 30 mm.; B.W., about 5.0 mm. Ultimate: H.W., about 3.42 mm.; B.L., about 35 mm.; B.W., about 5.3 mm.

Remarks: The descriptive notes were prepared from one larva (Forest Insect Survey, Record No. 1952 Alberta 256B) collected on May 27, at Morley, Alberta, on trembling aspen; pupation date unknown; male emerged September 29.

Larvae of *H. carbonaria* key out to *H. hircina* Morrison or *H. dives* Smith in Crumb (1956).

Amphipyrinae

OLIGIA ILLOCATA Walker.

Range: Nova Scotia to Pennsylvania, west to Colorado and British Columbia (Forbes, 1954).

Hosts: Species of *Alnus* and *Salix*, and *Shepherdia canadensis* (L.) Nutt.

Life History: Larvae in June and early July, free-living; pupae in mid-summer; adults from late August to early October.

Description: *Penultimate*: Head pale brown. Thorax and abdomen pale grey, heavily mottled with purplish-brown on dorsum; middorsal, supraspiracular, and spiracular lines fine, white. *Ultimate*: Head brown. Thorax and abdomen pink or purplish-brown; middorsal, supraspiracular, and spiracular lines fine, white; venter almost white. No. of larvae examined: 2.

Measurements: Penultimate: H.W., about 2.0 mm.; B.L., 20 mm.; B.W., 3.0 mm. Ultimate: H.W., 3.04 mm.; B.L., 33-38 mm.; B.W., 3.5-4.0 mm.

ANDROPOLIA CONTACTA Walker (Figs. 6 and 9).

Range: Nova Scotia (Ferguson, 1955) to British Columbia (Jones, 1951) in Canada; New Hampshire, New York, west to Utah and Washington, in United States (Forbes, 1954).

Hosts: Commonly *Populus tremuloides* Michx.; also species of *Salix, Alnus*, and *Betula*.

Life History: Larvae, free-living, in June and July; in pupal stage for about three weeks; adults in August and September.

Description: *Early stage*: Head brown; thorax and abdomen grey, mottled, with faint white middorsal and supraspiracular lines; spiracular line grey with black sinuate line above; subspiracular region pale grey; venter grey, mottled. Prothoracic plate black with white subdorsal lines crossing it. Thoracic legs black; prolegs grey with black markings. *Antepenultimate*: Pattern much as in early stage. *Penultimate*: Head grey with darker grey reticulations. Thorax and abdomen grey with dark grey obliques on dorsum; dark grey transverse marking on dorsum of eighth and ninth abdominal segments; remainder of body patterned as before. *Ultimate*: Head pattern much as in penultimate stage. Thorax and abdomen coloured much as in penultimate stage but pattern more diffuse, with less contrast; the black sinuate line of spiracular region may be straight in this stage. No. of larvae examined: 10.

Measurements: Early: H.W., 0.80-0.85 mm.; B.L., 10 mm.; B.W., 1.0-1.2 mm. Antepenultimate: H.W., 1.33-1.52 mm.; B.L., about 13 mm.; B.W., about 1.5 mm. Penultimate: H.W., 2.41-2.66 mm.; B.L., 15-23 mm.; B.W., 2.0-4.0 mm. Ultimate: H. W., 3.80-4.18 mm.; B.L., 33-44 mm.; B.W., 5.7-7.6 mm.

ENARGIA INFUMATA Grote (Fig. 8).

Range: Nova Scotia to British Columbia, and south to California.

Host: *Populus* spp.

Life History: Larvae, feeding in a shelter of leaves tied together, from late May until early June; pupation in June and early July; adults from middle of July until middle of September.

Description: *Penultimate*: Head pale brown, with or without brown suffusion over parietal lobes; clypeus usually with brown dash along median line. Thorax and abdomen whitish with fine white lines in middorsal, supraspiracular, and spiracular regions. *Ultimate*: Head patterned as above. Thorax and abdomen patterned as in penultimate stage. No. of larvae examined, 10.

Measurements: Penultimate: H.W., 1.90-2.28 mm.; B.L., 17-20 mm.; B.W., about 2.0 mm. Ultimate: H.W., 3.04-3.55 mm.; B.L., 15-30 mm.; B.W., 3.8-4.5 mm.

Remarks: Larvae of *E. infumata* Grote and *E. decolor* Walker (Comstock, 1937; Crumb, 1956) differ in two characters. The head of *E. decolor* is unmarked but that of *E. infumata* usually has brown markings on the clypeus and often on the parietal lobes. The head widths of Alberta larvae of *E. infumata* are from 3.04 to 3.55 mm. and of *E. decolor* from 3.55 to 4.00 mm. Crumb (1956) notes that the head widths of *E. decolor* are from 3.1 to 3.2 mm. so that the latter character may not be satisfactory over a wide range of material.

Catocalinae

SYNEDOIDA HUDSONICA Grote and Robinson.

Range: Hudson Bay to Alaska, to California and Colorado, Nebraska, North Dakota, and Manitoba (Richards, 1939).

Host: *Shepherdia canadensis* (L.) Nutt.

Life History: Larvae, free-living in later stages but feeding in shelter of a rolled leaf in early stages, in July and August; hibernate as pupae; adults from June to August.

Description: *Penultimate*: Head pale grey with grey lines over parietal lobes; thorax and abdomen pale grey; middorsal line fine, brown; grey oblique markings on dorsum. *Ultimate*: Head grey with dark grey lines. Thorax and abdomen grey with dark grey obliques on dorsum. No. of larvae examined: 10.

Measurements: Penultimate: H.W., about 1.70 mm.; B.L., about 13 mm.; B.W., 1.9 mm. Ultimate: H.W., 2.28-2.66 mm.; B.L., 20-33 mm.; B.W., 2.66-4.00 mm.

SYNEDOIDA PETRICOLA Walker.

Range: Colorado, Utah, Montana; British Columbia east to Manitoba (Richards, 1939).

Host: *Hedysarum* sp.

Life History: Larvae feed in August; hibernate as pupae; adults in June and July.

Description: *Ultimate*: Head pale brown with rust-coloured stripes over parietal lobes: Thorax and abdomen pale brown; middorsal stripe pale brown with fine brown median line; dark brown addorsal line; sides brown; venter pale brown with fine brown median line. No. of larvae examined: 1.

Measurements: Ultimate: B.L., 30 mm.; B.W., 3.0 mm.

Remarks: Description based on one larva, McG. 55-69B, collected August 25, 1955, on the Kananaskis Forest Experiment Station, Seebe, Alberta; the larva pupated September 1 and emerged after hibernation as a male.

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Two-Year Life Cyle of *Pseudohazis eglanterina* (Boisduval) (Lepidoptera: Saturniidae)[1]

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A considerable amount of literature has been published on the genus *Pseudohazis* and its species but there is only one brief mention of the possibility of a two-year life cycle (Dyar 1904). Several rearings of *P. eglanterina* form *normalis* Dyar, completed by the author, have provided conclusive evidence that a two-year cycle is the usual life history pattern in southwestern British Columbia. One such rearing is herein described. This two-year cycle, the first winter in the egg stage and the second winter in the pupal stage, is not in phase as mature larvae and adult moths may be found in the same area at the same time. Detailed descriptions of larval and adult stages are in Dyar 1894 and Packard 1912. Acknowledgment is due to Dr. E. G. Munroe, Unit of Systematic Entomology, Ottawa, for his assistance in reviewing literature and specimen material.

P. eglanterina occurs throughout southern British Columbia at all but the highest elevations. The form usually found on Vancouver Island and the southwest mainland is *normalis*, which extends eastward at least to the Okanagan Valley. Although the insect is not rare it is restricted to comparatively warm and sunny locations and is seldom encountered. The rapid-flying adults are usually observed during brilliant mid-day sunshine in calm semi-open areas. The larvae, which are colonial for most of their lives, feed on *Rosa* spp., *Holodiscus* spp., *Amelanchier* spp., *Populus tremuloides* Michx., *Salix* spp., *Centaurea cyanus* Linn., and probably utilize many other shrubby plants. *Pseudohazis* is usually found away from human habitation and there is no record of it from gardens. It has never been reported as causing damage in British Columbia.

On July 13, 1955, at Langford, British Columbia, a male and female typical of *P. eglanterina* form *normalis* were found in copulation. They were resting on a low grass tussock fully exposed to the bright noon sun. The area was relatively sheltered from the wind and the temperature was approximately 80°F. The moths remained quiescent for several minutes and were then collected and caged. At dusk the female commenced laying eggs and by the following day three egg masses totalling 236 eggs had been deposited on fine spiraea twigs (*Holodiscus discolor* (Pursh) Maxim.). The egg masses contained 22, 81, and 133 eggs. Each egg was a flattened ovoid approximately 1.9 mm. x 1.5 mm. x .9 mm., attached at one end to the twig by a small amount of clear adhesive. Each egg projected more or less at right angles to the twig, with its flattened side on a horizontal plane. The female moth placed the eggs individually from her position higher up the twig, at 10-20 second intervals. The base of the egg ring was established and the other eggs added in an irregular pattern tending towards diagonal rows. Although the eggs touched each other they were not united. The male moth evinced no interest in the female after the initial mating.

At first the colour of the eggs was an unmarked pale yellow-green. The eggshell was very finely reticulate with a small dimpled micropyle at the apex. By the seventh day the colour had darkened to a bluish-green and an irregular light coloured patch had appeared at the apex. Three weeks later the colour had become dark pearly-grey with many fine white speckles, and the tip of the egg was deeply dimpled. At this time it was possible to observe the indistinct outline of the developing larva coiled in the egg. By the 37th day the chorion

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TABLE I
Rearing data for larvae of *P. eglanterina*

Instar	No. of larvae	No. of days per instar			Date of moult		
		Minimum	Mean	Maximum	First	Mean	Last
I	182	8	8	8	May 7	May 7	May 7
II	96	8	8	8	May 15	May 15	May 15
III	69	9	10	11	May 24	May 25	May 26
IV	54	9	11	12	June 3	June 4	June 5
V	39	12	14	15	June 16	June 18	June 19
VI	29	14	16	19	June 30	July 4	July 6
VII	21	19	22	29	July 23	July 26	July 31

was translucent, milky-white in colour and the larva inside was well formed and clearly visible. The winter was passed in this condition with little change except for the increasing transparency of the chorion and the gradual disappearance of the fluids surrounding the larva. The eggs were kept for eight weeks in a moderately humid atmosphere at room temperatures ranging from 50°-80°F., then moved to insectary temperatures of 20°-65°.

Hatching commenced April 29, 1956, during temperatures of 42°-62°F., and continued for four days by which time approximately 77 per cent of the larvae had emerged. Each larva chewed a regular elliptical exit approximately .5 mm. x .7 mm. at the tip of the egg. Table I shows the chronology of the larval rearing. Mortality was caused mainly by dehydration, preservation of some larvae for study, and some failure to moult properly.

The larvae were active immediately on emerging and crawled back and forth over the egg mass and along the spiraea twigs leaving fine silk trails. Groups of 4-38 larvae began feeding, but within 36 hours these groups united to form

TABLE II
Body lengths and head-capsule widths of larvae of *P. eglanterina*

Instar	Total body length in mm.			Head-capsule width in mm.		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum
I	3.8	4.6	5.0	.81	.86	.89
II	5.1	5.8	6.7	1.00	1.07	1.13
III	8.4	9.6	10.7	1.24	1.30	1.37
IV	13.2	14.7	16.7	1.90	2.02	2.16
V	19.4	22.2	25.5	2.48	2.61	2.80
VI	30.6	35.8	39.4	3.22	3.36	3.48
VII	41.8	52.2	55.3	3.80	3.95	4.06

one large colony that fed, rested, defended, travelled, and moulted en masse. The colony partly dispersed when the fourth instar was reached, but subcolonies persisted until early in the sixth instar. Larvae in the ultimate or seventh instar did not eat for the final 10-13 days of the stage and during that time crawled around in the cage duff. The pupae were formed in shallow pits just below the surface litter, without any cocoon or webbing. They averaged 30.0 mm. in length and 11.1 mm. at the maximum diameter. They overwintered in slightly moistened sand at outdoor temperatures ranging 16°-76°F. Adults emerged from July 17 to July 30, 1957. The male to female ratio was approximately 3:2. Table II shows larval measurements. Twenty larvae were selected at random from each instar for the data.

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(Revised October 17, 1957.)

A New Subspecies of *Sparagmia gigantalis* Guenée (Lepidoptera: Pyralidae)[1]

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Specimens recently received for identification from Dr. C. Bernard Lewis, Institute of Jamaica, Kingston, proved to belong to the widely distributed Neotropical species *Sparagmia gigantalis* Guenée, described from Nouvelle-Fribourg, Brazil. These specimens agree with others from Jamaica in the collection of Mr. N. Shoumatoff, New York, in having the ground colour of a much brighter orange than in South American specimens, in having the transverse lines somewhat weaker, and in having the submarginal violaceous patch of the fore wing relatively pale. These characters are not duplicated in the long series from various parts of Central and South America with which I have compared the Jamaican specimens, and I accordingly designate the latter as *Sparagmia gigantalis shoumatoffi*, new subspecies, with type material as follows: Holotype, male, "Monigue" [Moneague], St. Ann, Jamaica, July 19, 1933, A. Avinoff and N. Shoumatoff; allotype, female, Baron Hill, Trelawny, Jamaica, October, 1931, Lilly Perkins; one male paratype, Greenhills, Hardwar Gap, Jamaica, July 17, 1936, E. Paine; these specimens in the collection of N. Shoumatoff, deposited at the Carnegie Museum, Pittsburgh. Additional paratypes as follows: in the Canadian National Collection, one male, Christiana, Jamaica, August, 1940, and one female, Jacks Hill, St. Andrew, Jamaica, Aug. 5, 1951, J. V. Neish, type No.

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6460, C.N.C.; in the Institute of Jamaica, one male, Jacks Hill, St. Andrew, Jamaica, Aug. 5, 1951, J. V. Neish, this specimen with most of the fore wing suffused with dark brown.

I am very much indebted to Mr. Shoumatoff, to Dr. Lewis, and to Mr. H. K. Clench, Carnegie Museum, Pittsburgh, for the loan and gift of material.

(Received August 16, 1957)

Book Review

THE BEETLES OF THE PACIFIC NORTHWEST. PART II: STAPHYLINIFORMIA by Melville H. Hatch with the collaboration of Milton W. Sanderson and Gordon A. Marsh. 38 pp. 37 plates. University of Washington Publications in Biology, Volume 16, 1957.

The second volume of Professor Hatch's ambitious work on the beetles of the Pacific northwest covers the families Silphidae, Leptinidae, Leoididae, Staphylinidae, Scydmaenidae, Scaphidiidae, Clambidae, Corylophidae, and Ptiliidae. Over two hundred new species and a number of new genera are described, and this fact alone makes the book essential for taxonomists concerned with our fauna in these groups.

Professor Hatch is to be complimented for endeavoring to bring some order to a large and difficult group; nevertheless, there are some instances in which previous confusion may have been compounded. The specialist and the nonspecialist alike may find portions of the book difficult to use, as all the descriptive material is included in the keys except in the Steninae, and this makes them ponderous and time-consuming to use. In some cases both sexes are needed to use the key; in others only males are considered. Also, in the key to species of the genus *Gabrius* (p. 198), the first couplet is based on females only, whereas the second couplet deals only with males, thus rendering the key nearly useless. In many cases (e.g., genus *Catopocerus*, p. 19-21) new species are described in the keys from only the male, yet a female allotype is designated without descriptive material. Other departures from well-established practices include the use of hyphenated specific names and the omission of indication of new synonymy.

Despite the shortcomings, the reviewer found, in running a number of specimens through the keys, no more difficulty than might reasonably be expected in dealing with such a large group. The keys in the portion on Scydmaenidae by Mr. Marsh are similar to those of Professor Hatch. On the other hand, the section by Dr. Sanderson on the Steninae (pp. 246-271) appears excellent, with short keys and separate descriptions. All the illustrations appear well done except plates five and six, which are poorly reproduced in the review copy. It may be added that many of Dr. M. T. Jame's remarks in his review of the first part of this work (Annals Ent. Soc. America, 1954, Vol. 47, p. 247) are also applicable to this second part.

H. F. Howden

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